Fruit SCIENCE

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Fruit Science

To

THE YOUNG PEOPLE OF TODAY

Who will be the leaders of
the fruit industry tomorrow

Fruit Science

Orchard and Small Fruit Management

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Preface

This book on deciduous fruit growing has been prepared primarily for use in undergraduate pomology courses in colleges of agriculture. The discussion and terminology have been simplified as much as possible so that the book also can be used as a reference or text in vocational agriculture classes and short courses. In addition, it is hoped that the book will be of value to the fruit grower himself who believes that he has not mastered some of the details of his business and who desires to keep abreast with trends and research developments.

A somewhat different pattern of subject-matter presentation has been followed in this book as compared with most fruit growing books. The first two chapters are general and refer to all deciduous fruits to be discussed. The next few chapters are devoted entirely to the apple since it is the most widely grown and important deciduous tree fruit. The apple chapters cover in more or less detail the important subjects from soil management to marketing. By this presentation, the student will have opportunity to become acquainted with the scientific principles upon which the different practices in apple growing are based, and with this foundation he should be able to understand and devise solutions for problems with other deciduous fruits. Actually, for all practical purposes, there are few great differences among fruits with regard to their growth processes, fruiting responses, and cultural requirements.

The remaining chapters in the tree-fruit section largely cover the management of other important deciduous fruits only in so far as they differ from the apple. This section is followed by three general chapters covering respectively, insect and disease control, judging and exhibition contests, and freezing preservation of fruits. In the next section on small fruits, each discussion is complete for the fruit in question. It is generally true that the above sequence of information is more or less followed in presenting basic pomology courses in state colleges of agriculture; by far the greater majority of the discussion of principles and practices in fruit growing is devoted to the apple.

There is much variation in methods of teaching fruit growing and results obtained; the instructor's organization and method of presentation of material appears to be the most important factor governing student interest. Each instructor has a personal pattern of presentation, and the system which works well for one person may make a poor showing for another. In the author's experience, the above system of presenting a full picture of one fruit at a time seems to be less confusing to the student than when, for example, several pruning methods for a wide variety of fruits are jumbled together in one or two lectures. When such a discussion is concluded, most students cannot seem to recall what practice should be used on which fruit. If a student studies and thinks only one fruit from the time the varieties are selected until the product is sold, the whole picture unfolds as a story with a beginning and an end, and experience seems to indicate that he retains more accurate information about that fruit during and after the final examination for the course.

The plan of presentation in this book should also lend itself to certain states or regions where some fruits are of little or no importance. For example, much less time would be devoted to cherries in Maine than in Michigan. The cranberry merely would be mentioned in Missouri, whereas it is of outstanding importance in Massachusetts. The subject matter is also more readily available to the fruit grower specializing in but one or two fruits. If a peach grower desires information on pruning, soil management, harvesting, and other practices, he finds it in one chapter, and, thus, it is not necessary for him to thumb through long general chapters on each orchard-management phase to pick out those particular practices relating only to the peach.

The recommendations in this text are based on experimental results in both this and foreign countries. At the end of each chapter under the heading of "Suggested Collateral Readings," appears a list of selected references. This list of references is by no means exhaustive. It includes publications with not only additional information, but frequently extensive bibliographies from which the reader can broaden his study. Included with each chapter are also a number of simple review questions which the student or instructor can use to review the main points covered. The entire lecture material presented in this text should be easily covered in about thirty-five lectures, which is approximately standard for most college fruit-growing courses.

Many pomology instructors are making use of 35mm. color slides to enlighten fifty-minute discussions and to get points across more effectively. Moving pictures may be desirable in some cases for showing procedures, but the 35mm. slides have proven more practical and economical for general use. Some instructors have accumulated many of these slides while making routine tours of fruit plantings. The slides are labeled, dated, and filed in groups in quickly available order according to subject matter or to discussion period. Projection machines are available for systematically loading two dozen or more slides in a magazine at the beginning of the lecture and projecting them by push button at the lecture desk. Such an arrangement is valuable for reducing interruptions during the discussion and projection periods.

The professional men who carefully reviewed and criticized different portions of the manuscript deserve considerable credit and appreciation. All showed a genuine interest and an excellent spirit of co-operation which provided much encouragement to the author during the preparation period. The chapters and respective reviewers are as follows: "Introduction" and "Cherry Culture," *Director Victor R. Gardner,* Michigan Experiment Station; "Establishing the Fruit Planting," *Mr. John T. Bregger,* U. S. Soil Conservation Service; "Soil Management for Apples," *Dr. J. K. Shaw,* Massachusetts State College; "Flower Bud Formation, Pollination, and Fruit Set in the Apple," *Dr. Arthur E. Murneek,* Missouri Experiment Station; "Thinning Apple Fruits," *Dr. Melvin B. Hoffman,* Cornell University; "Grafting and Budding," *Professor H. A. Cardinell,* Michigan Experiment Station; "Freezing Injury to Apples," *Dr. J. H. Waring* and *Dr. M. T. Hilborn,* Maine Experiment Station; "Harvesting and Packing Apples," *Dr. Robert M. Smock,* Cornell University; "Storing Apples," *Dr. Roy E. Marshall,* Michigan Experiment Station; "Marketing Apples," *Mr. D. F. Fisher,* U. S. Department of Agriculture; "Pear and Quince Culture," *Dr. Luther D. Davis,* California Experiment Station; "Peach, Nectarine, Apricot, and Almond Culture," *Dr. Frank P. Cullinan,* U. S. Department of Agriculture; "Plum Culture," *Dr. L. L. Claypool* and *Professor C. J. Hansen,* California Experiment Station; "Insect and Disease Control," *Dr. Walter S. Hough,* Virginia Experiment Station and *Mr. Max McFee,* John Bean Manufacturing Company; "Judging and Exhibition Contests," *Dr. I. C. Haut,* Maryland Experiment Station; "Freezing Preservation of Fruits," *Dr. Donald K. Tressler,* Food Consultant; "Grape Growing," the late *Prof. F. H. Beach,* Ohio State University; "Strawberry Growing," *Dr. George M. Darrow,* U. S. Department of Agriculture; and "Bush Berry Culture," *Mr. Stanley Johnston,* Michigan Experiment Station. It should be pointed out that none of the above men has seen the final draft and, therefore, is in no way responsible for the errors that may appear.

Several individuals showed more than the usual kindness in assembling photographs, obtaining special data, or in helping with other matters. They include: Dorothy Chase, Publications Department, Cornell University; J. E. McClintock, Agricultural Editor, Ohio State University; Paul L. Koenig, U. S. Department of Agriculture; Dr. Archie Van Doren, Department of Horticulture, Washington State College; Professor Juan Labadie Eurite, Department of Agricultural Economics, University of Puerto Rico; Dr.

Kenneth A. Bartlett, Director, Federal Experiment Station in Puerto Rico; and Dr. David G. White, Professor of Pomology, Pennsylvania State College. The photographs which were graciously furnished by workers in pomology or other people closely associated with the fruit growing business, are acknowledged in the respective legends. Remaining photographs and diagrams were for the most part either taken or prepared by the author.

Much gratitude is due the late Dr. Joseph H. Gourley for suggesting the preparation of this book. Also, the patience and advice of Dr. R. W. Gregory, Agricultural Editor for Lippincott, are indeed appreciated. Mrs. Dorothy Bell Childers gave untiring assistance in typing the manuscript, arranging the photographs, making certain diagrams, and in reading proof. Without her help and encouragement, this book probably would not have been completed.

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Fruit Science

CHAPTER I

Introduction

Early settlers landing on the east coast of America brought with them many fruit plants and seeds from their native lands. The different kinds and varieties of fruits, many of which are commercially important today, were rapidly propagated and distributed to the South and West by religious workers, travelers, pioneer farmers, and such well-known characters as Johnny Appleseed. By the early 1900's, commercial fruit growing began to develop in earnest along the Pacific slope until now some of the highest producing fruit regions of the world are located in California, Washington, and Oregon.

At first, a number of the fruits were not well adapted to conditions in America from the standpoint of climate, disease resistance, storage, shipping, processing, and other factors. Gradually, interested individuals and later the Federal and state agricultural experiment stations, through chance selection or scientific breeding, enlarged the list of high-quality varieties commercially grown today. The great development of the fruit industry was probably due for the most part to the delicious eating quality of the products, although their proclaimed health value no doubt played an important role.

The technique of growing fruits has undergone a marked change during the past fifty years. In the early 1900's, fruit growing was rather simple as compared with the many steps and different types of machinery involved today. Where formerly little or no spray material was applied, now as many as ten to fifteen sprays are applied to apples in one season. The need for more spraying was brought about by an increase in number of insects and diseases and greater resistance of some species to standard spray materials. Much of the apple crop was formerly harvested and sold directly out of the orchard with comparatively little grading and packing. Now, most of the commercial crop is carefully washed, graded, sized, and packed with the aid

Richard Whittington, Los Angeles

Figure 1. An orchard scene in California, the leading fruit state. Although citrus comprises a large part of its fruit industry, California also leads in grapes, peaches, plums, prunes, nectarines, pears, sweet cherries, apricots, almonds, walnuts, persimmons, olives, figs, avocados, and dates. California also ranks high in apple and strawberry production.

of specialized machinery. A large part of the crop may then be placed in cold storage for several months before being sent through established marketing channels. Obviously, the amount of labor and equipment required to grow and prepare fruit for sale has increased. Also, about twice as many bushels of apples are required to pay the annual wages of a hired man as compared with the amount required in 1910. Although modern machinery has made it possible to increase man's efficiency in output, this gain has often been passed on to labor in awarding higher wages. Thus, the fruit grower must be increasingly more efficient in the use of his labor if he is to continue to enjoy profits above the wages paid.

Shortly after 1940, great advancements were made in new machinery designed to reduce high labor costs in fruit growing. An example is the modern power sprayer which requires only one or two men to spray a large orchard, whereas formerly, five to seven or more men were needed to do the same job in the same period of time. Although the initial cost of such machinery is relatively high, the greater output and long-time saving in labor costs justifies their use. It should be pointed out, however, that only those growers who can obtain high production per acre of high-quality fruit will

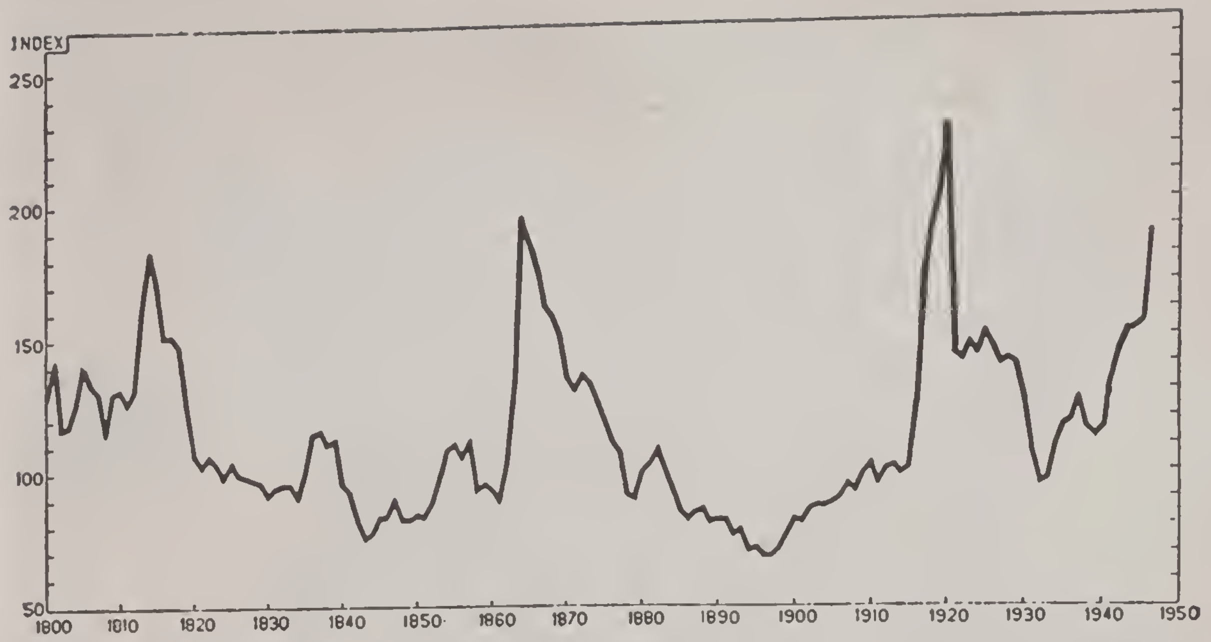


Figure 2. The general price level (1910-1914 equals 100) at which goods are bought and sold in the United States is either going up or down. The four price peaks and the depressions are associated with four wars. Profitableness of an apple orchard set in 1949 will be influenced by the price level from 1960 to 1980.

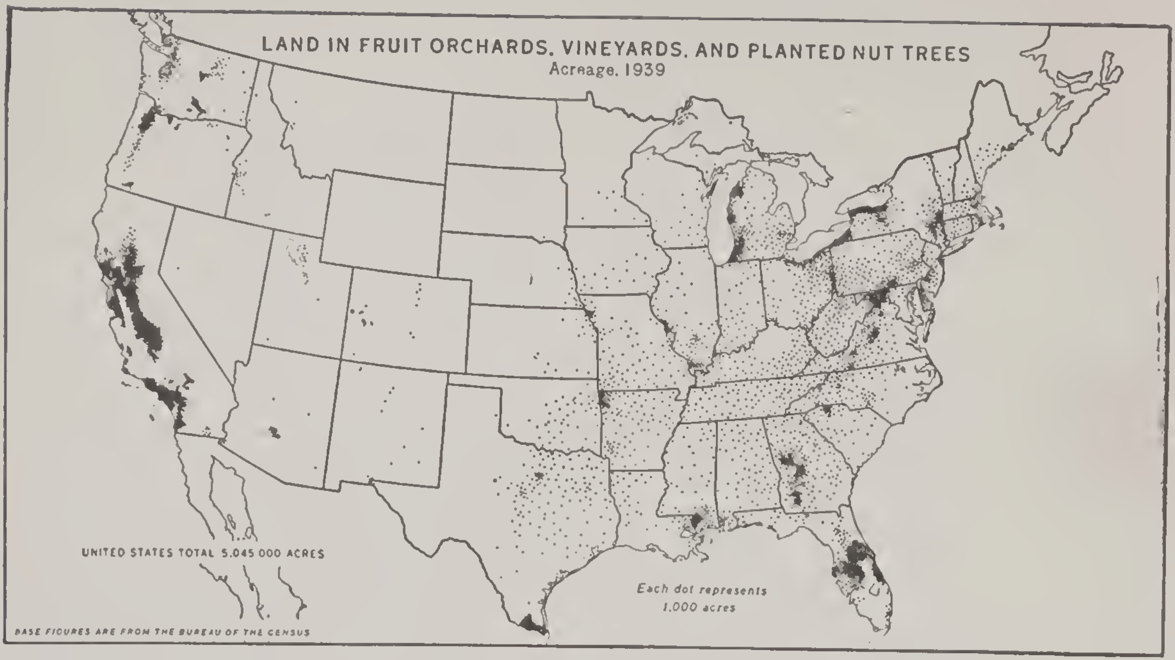
be able to adopt the improved but more expensive production machinery and methods.

Some economic principles. A chief concern of the man who desires to plant or buy an orchard is the future likelihood of profits. Obviously, no one can accurately predict the profits of an orchard due to so many variables. There are, however, some economic principles which frequently hold and which may be considered.

The most important factor influencing cash returns to fruit growers is the general price level, which is usually going up or down, as history shows in Figure 2. Note that the major rises in price level are correlated with four wars: the War of 1812, the Civil War, World War I, and World War II, respectively. The price level has never been stable for more than a ten-year period during the past 150 years.

In regard to World War I, it is of interest to note that the general price level remained high for two years after the war, when it declined sharply in 1920. It was not until eleven years later in 1929, however, that the price level collapsed and initiated the well-known depression of the early thirties. Prices in the United States may not follow precisely the same trend for a 20-year period after World War II, but the over-all general fluctuations are likely to be more or less similar, or perhaps even more violent in light of the increasing complexity of our economic organization.

In present-day agriculture, the fruit grower must buy supplies on the market in order to produce and sell his products. When prices are falling, the fruit growers, as with all farm operators, are at a disadvantage because they must pay a higher price for things they buy than the price they receive for things they sell. Before a man makes a long-time investment in an orchard, it would be well for him to determine if the price level is high or


LAND IN FRUIT ORCHARDS, VINEYARDS, AND PLANTED NUT TREES
Acreage, 1939
UNITED STATES TOTAL 5,045,000 ACRES
Each dot represents 1,000 acres
BASE FIGURES ARE FROM THE BUREAU OF THE CENSUS

U.S.D.A. Bureau of Agricultural Economics

Figure 3. Fruits are grown in every state of the Union, but there are definite well suited areas where each fruit reaches peak production. The particular fruit or fruits involved in the concentrated areas shown above are pointed out in subsequent chapters.

low, and if it is going up or down. There undoubtedly will be less foreclosures in the next 10 to 20 years if fruit growers will remember that rising prices at one time mean falling prices at some later date. The profitableness of an orchard set in 1949 will be determined by prices obtained for fruit products and the cost of things from 1960 to 1980. With small fruits such as strawberries, however, which bring full crops in two years after planting, the grower is in a better position to take full advantage of peak-price-return periods by increasing acreage accordingly.

The fruit industry. The United States ranks high in world fruit production. Among countries for which data were available in the 1940's, the United States lead in tree fruits, accounting for 41 per cent of the combined world crops of apples, pears, peaches, plums, prunes, oranges, grapefruit, and lemons. Of the individual fruits, the United States produced about the following percentages: apples, 22; pears, 23; peaches, 69; plums and prunes, 39; oranges and tangerines, 96; and lemons, 48.

Regions in which fruits and nuts are grown in large commercial quantities in the United States are shown in Figure 3. The heaviest producing areas are located in the Far West and the eastern half of the United States. The densely speckled areas in the Northwest and Northeast can be largely attributed to apples, whereas those in the southeastern states, with the exception of Florida, largely represent peaches and pecans. In Florida, southern Texas, and southern California (Figure 3), the concentrated areas are principally citrus.

California is the leading fruit state, producing over one-fourth of the total United States fruit and nut crop. The relative farm value of its crop

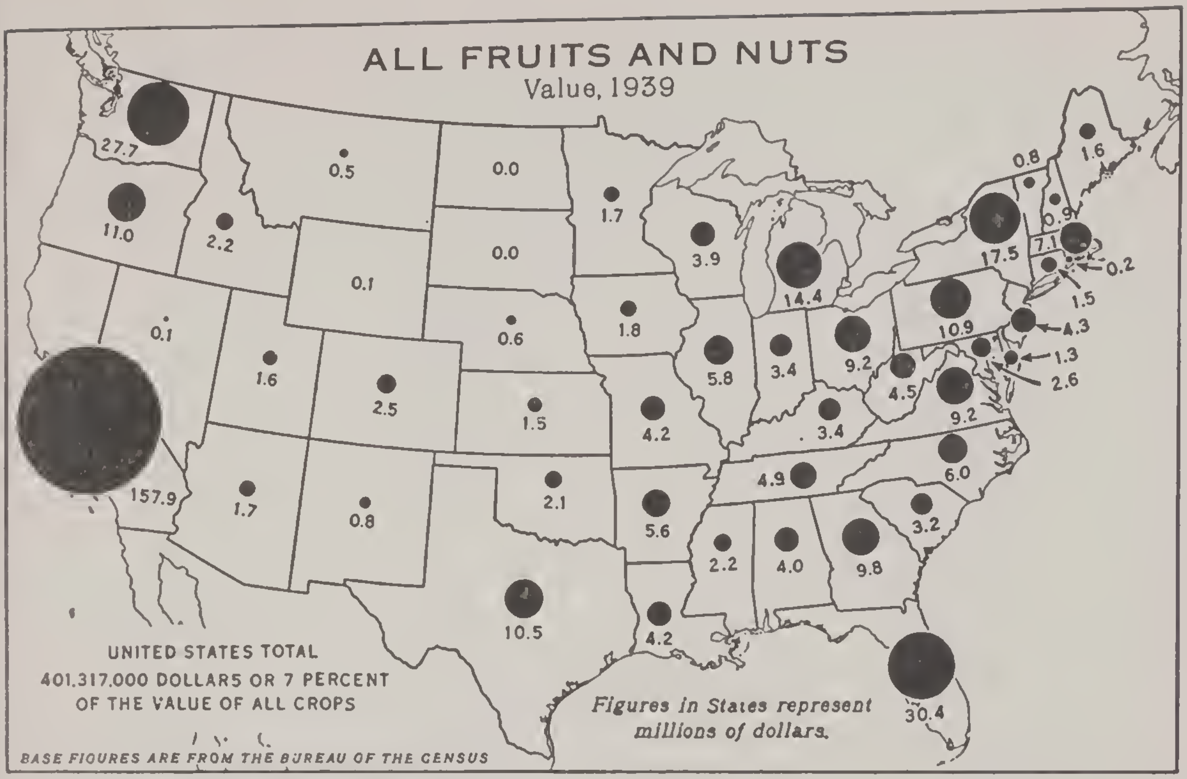


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Figure 4. The leading fruit states on the basis of value of all fruits and nuts produced are California, Florida, and Washington. There is a great need and a definite trend toward better handling and transportation of fruits from production centers to near-by or distant heavily populated areas in the Northeast. The goal is to get tree-ripened fruit to the consumer in unblemished, high-quality condition.

in 1939, as shown in Figure 4, was about 158 million dollars, which was five times as large as its nearest competitor, Florida. Almost every kind of fruit and nut produced in the United States can be grown in California due to its many climates, fertile soils, and elaborate irrigation systems. California produces both temperate fruits, such as the apple and peach, and tropical and subtropical fruits, such as citrus, avocados, and figs.

On a tonnage basis, the leading deciduous fruit grown in the United States is apples, as indicated in Table 1. It is closely followed by grapes and then, in order, by peaches, pears, prunes, apricots, strawberries, and cherries.

In the 15-year period ending in 1946, production of citrus had increased rapidly until the orange lead all other fruits in tonnage, with grapefruit and lemons also ranking high. On the other hand, the production of apples and peaches, two

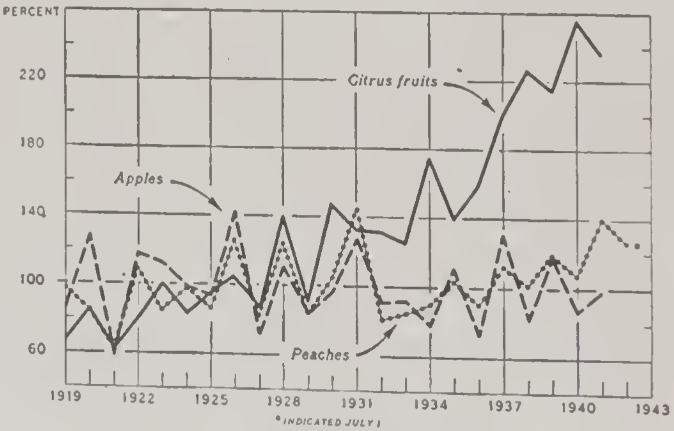

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Figure 5. Production of apples and peaches, two leading fruits, has remained about the same over the 25 years with a slight increase in peaches in recent years. Citrus, however, has shown a marked increase in production since about 1933.

TABLE 1

Relative Production and Importance of Fruits and Nuts in the United States

Fruit Crop	Commercial production in tons (based on 1934–45 average)[1]
Oranges and Tangerines (5)[2]	3,055,000
Apples (35)	2,903,088
Grapes (37)	2,552,730
Peaches (40)	1,438,512
Grapefruit (4)	1,437,000
Pears (42)	770,050
Prunes (4)	636,450
Lemons (1)	436,000
Apricots (3)	235,535
Strawberries (33)[3]	180,004
Cherries (12)	159,597
Figs (2)	102,871
Plums (2)	74,200
Walnuts (2)[3]	60,100
Pecans (12)	52,873
Olives (1)[3]	43,500
Cranberries (5)	31,205
Almonds (1)[3]	14,710
Avocados (2)	13,894
Dates (1)	5,825
Limes (1)	4,000
Filberts (2)[3]	3,896
Total	14,211,040

[1] Tonnage calculated from data issued by Bur. of Agr. Econ., U. S. Dept. of Agr., using conversion figures from "Approximate or average weights of commodities and other conversion factors," U. S. Dept. of Agr. Separate from Agricultural Statistics, 1941. No. 50. 1942.

[2] Number of states commercially producing the crop is given in parenthesis.

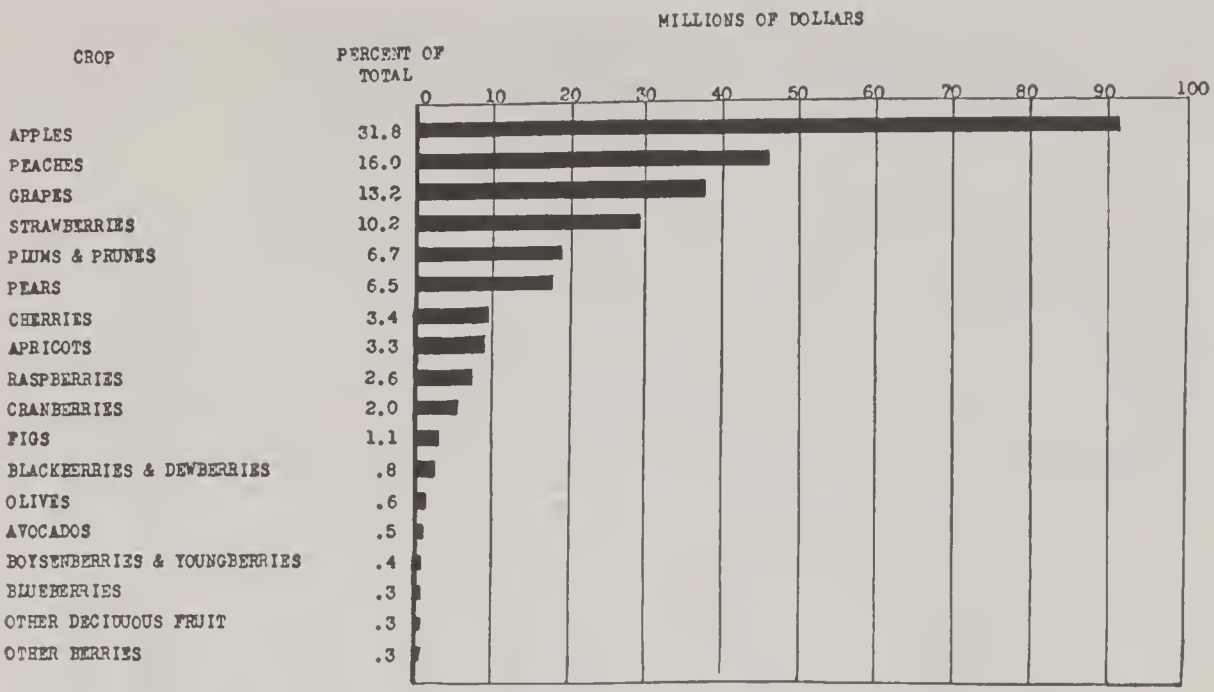
[3] 1935–44 average.

leading deciduous fruits, have remained approximately at the same general level since 1919.

The relative farm value of deciduous fruits in the United States for 1939, a more or less typical fruit-crop year, is shown in Figure 6. In comparing these data and those in Table 1, it is evident that the value and tonnage of apples and peaches are closely related, but the value of grapes is much less than that of apples and peaches on a tonnage basis. Strawberries, on the other hand, have a high value.

The relative acreage and farm value of fruits as compared with other important agricultural crops are given in Figure 7. It is apparent from these data that fruits have a relatively high value on the basis of amount of land occupied. Some crops, such as hay, wheat, and oats, on the other hand, have a comparatively low value.

During and shortly after World War II, record crops of many of the deciduous fruits were attained, due to the great world need for food and to the high prices being paid for fruits. The increased production was largely attained by over-all better care of plantings, by renovating old orchards and



Paul L. Koenig, U.S.D.A. Bureau of Agricultural Economics

Figure 6. Relative farm value of deciduaus fruits and berries for the full crap year, 1939. The apple crop leads and is about twice the value of the peach and grape crops.

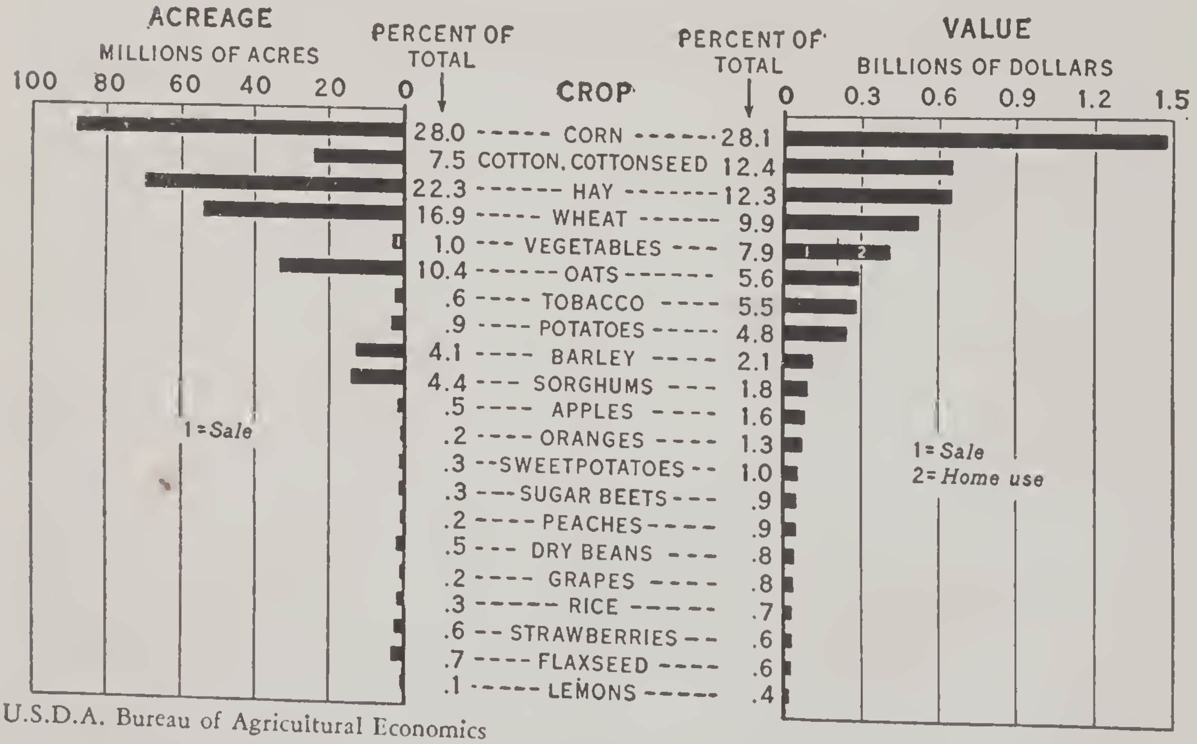


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Figure 7. Acreage and farm value af principal agricultural crops in the United States in 1939. Note that fruits as well as vegetables have a relatively high value on the basis of acreage occupied. Hay and wheat, hawever, have a low value. Total value of all agricultural crops in 1939 was less than six billion dollars.

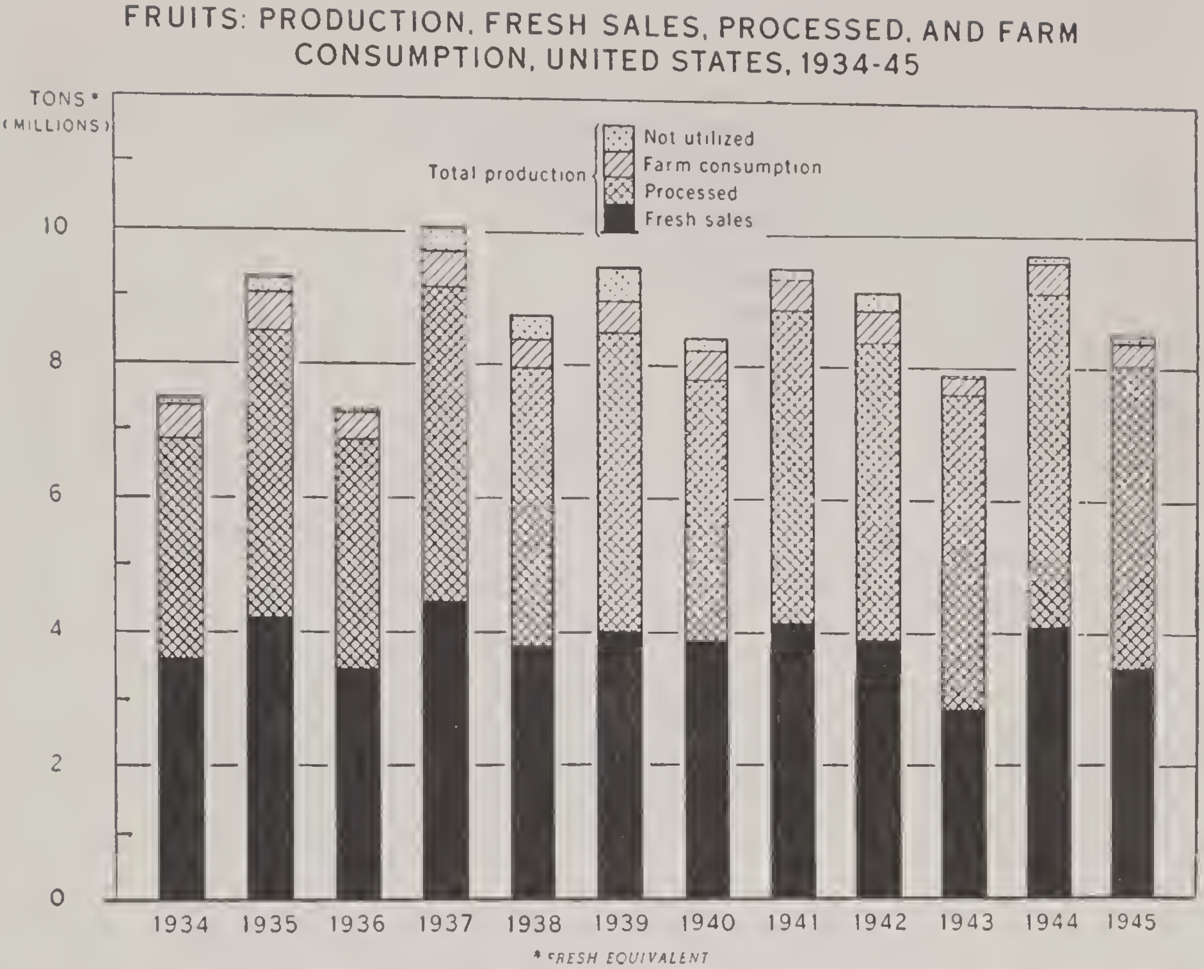

Figure 8. About half of the deciduous fruits produced are processed, indicating the importance of the processing field. The increasing trend toward fruit processing may continue for some time in light of the growing popularity of quick freezing and pure fruit juices.

vineyards, and by some new plantings, both before and during the war period. Inasmuch as general over-all increases in fruit acreage are attended with some risk, the individual grower might well exercise caution in increasing his own acreage during such periods.

Trends in fruit growing. Those people who believe in the philosophy of "an unfinished world" will be constantly looking into the future and making plans accordingly. The following trends in fruit growing indicate a wholesome symptom of progress.

In the past, many fruit growers have made it a practice to devote full time to raising only one fruit such as apples or peaches. Some growers are continuing this practice with good success. But there is a trend toward diversification in fruit growing because it frequently results in better year-round use of labor, a wider and more profitable market outlet, and better distribution of cash returns for the year as a whole. Perhaps not everyone should diversify, but some growers may have an interest in raising several different kinds of fruits, or, a certain amount of vegetables, bees, nursery stock, or livestock such as poultry, depending upon local opportunities and markets in these lines. It would be well to exercise caution, however, and not expand these activities to the point where the fruit planting suffers from lack of

M. C. Audsley and P. A. Wells, U.S.D.A.

Figure 9. This Eastern Regional Research Laboratory at Upper Darby, Pennsylvania (there is a similar one in California) is an indication of the great research effort being made by the U.S. Department of Agriculture to find new and better uses for fruit by-products.

proper attention. This situation has been a common mistake in the past with diversification.

During recent years there has been an increasing tendency of the apple grower to rotate his orchard with respect to age. This gives him opportunity to plant the newer and better varieties. Also, younger trees under average orchard care tend to produce a better-quality product at less cost. Under this system, the land available for orcharding is planned so that a new block of trees is set every five to ten years and an old block removed at about the age of 30 to 35 years. While this is particularly true with apples, it may be worthwhile with other tree fruits. Probably too much emphasis has been placed in the past on "permanent trees." They may have been *too* permanent.

In spite of the best orchard management, there will always be a certain amount of low-grade fruit. Every effort should be made to offer this fruit to the consumer *only* through processing channels. Fruit processing will no doubt undergo considerable future expansion. The importance of this field is emphasized in Figure 8 which shows that about half of the deciduous fruits produced are processed. A slight increase was noted in fruit processing during World War II and this increase may continue in light of the growing interest in quick freezing and pure fruit juices, the latter of which will undoubtedly furnish increasingly stiff competition for synthetic drinks. It is a debated question if dehydrated fruits will gain in popularity, but it is certain that some kind of new fruit products will be devised as a result of the vast amount of research being conducted in this field.

Much needs to be done in improving transportation and marketing systems for deciduous fruits, all of which are more or less perishable. The importance of the fruit marketing field is evidenced by the fact that about 60 cents of the consumer's dollar for apples goes into marketing channels, and the remaining 40 cents goes to the grower. Fruits that unquestionably find the quickest sales at the highest prices are those that are tree-ripened, of high quality and undamaged. In the past, the merchandizer and the fruit grower have blamed each other for bruised unattractive fruit, but this does not solve the problem for the consumer who wants a top product and is usually willing to pay a good price. The handling of fruit from tree to table needs increasingly more study and careful attention by the grower, experiment station worker, and by the merchandizer. Definite advancements are being made in fruit grading and sizing machinery and in special packaging to reduce bruising. There is also a definite trend toward more cold storages on farms in which the ripening processes of harvested fruit can be quickly reduced to a minimum. Precooling and better refrigeration conditions for fruit in transportation are receiving more widespread use. Air freight is showing considerable promise for quick long-distance transportation of fruits at the "eating-ripe" stage of maturity. Air freight is particularly promising for ripe strawberries which can be sent overnight from the winter gardens of the South to the industrial areas of the Northeast. Air-freight shipment of fruit is bound to show an increase in the future.

The field of consumer education is in need of more attention. It is surprising how little the general public knows about the proper buying and use of fruits. Cooking schools offer a good opportunity for teaching housewives how to buy the different varieties of fruit in season and for specific uses. Also, a more widespread educational program for retail dealers is greatly needed on how to handle and display deciduous fruits in the stores and markets. Each fruit offers an individual problem in this respect, which is often quite different from that of citrus. Too many retailers handle apples as if they were oranges or grapefruit.

The fruit grower. In spite of great advancements in ways and means of growing fruit and in the amount of scientific knowledge available, the most important factor in successful fruit growing is the grower, himself. In order to make a good living today, a fruit grower or any business man must have first a thorough and well-rounded practical knowledge of his business which comes only with considerable experience. If a good practical knowledge can then be reinforced with a college training or its equivalent in such subjects as botany, horticulture, plant pathology, plant physiology, chemistry, entomology, and agricultural economics and engineering, the grower is in a much better position to lead and compete with the best men in the business. A technical training in fruit growing is becoming increasingly important because of the many technical problems arising in what has become a scientific business. Among numerous other things, the fruit grower today must understand the complicated mechanisms of tractors and fruit washers; he must be a semiexpert on refrigeration; he must understand the fundamental physiology and anatomy of his plants, the chemistry of his spray materials and the physics of their applications; and he must be acquainted with the life cycles of the important insects and diseases encountered in fruit plantings. Furthermore, he must have a basic knowledge of the economics and marketing of his fruit.

In order to keep abreast with new scientific developments in the fruit growing field, growers must spend considerable time in reading and developing a collection of bulletins, books, professional magazines, and weather and crop reports. In addition, growers should make it a practice to attend and take part in local and state horticultural society meetings. Such meetings not only provide an opportunity to study new developments in fruit growing, but to compare notes with other growers, and to discuss special problems with professional and commercial men. Horticultural meetings, as well as competitive exhibitions of fruit, usually have the fine quality of stimulating a real ambition among growers to go home and do a better job of producing higher quality fruit.

In every group of growers, there are invariably some who are outstandingly more successful than the group as a whole, even during the most trying years. True, they may have a large established physical unit and sufficient capital to back the business, but there are usually other more important reasons in the final analysis. Among other qualities, including those suggested above, the successful grower is usually a steady hard worker and thinker; he is systematic in performing every job from pruning and spraying to keeping an accurate account of expenses, cash income, and net returns; and above all, he is a good administrator in picking able assistants and laborers, keeping harmony among them, and in accomplishing the maximum amount of work with the labor and facilities at hand. He is always open to new developments, but usually seeks first the advice of qualified professional men, then experiments cautiously in his own orchard before entirely discarding the old and tried methods for the new.

An interesting business. Most everyone has a certain leaning toward country life and some kind of farming. Boys raised on a fruit farm often continue their life work as a fruit grower if the business is bringing satisfactory returns. The city boy who desires to specialize in fruit growing must recognize at the outset that he is at a great disadvantage among young men who have been raised on the farm. It requires considerable hard work for the city boy entering college to acquire the practical knowledge of fruit growing and at the same time gain a technical training in college. Young men from the city who want to specialize in fruit growing should make every effort to get practical orchard experience during summer vacations or by taking a full year off from college if necessary before attempting to enter the fruit growing business. Practical experience is equally essential before entering the fields of research, teaching, or the commercial sales and handling of materials used in fruit growing. Thus, the young city man who becomes interested in fruit growing while attending college should by no means be entirely discouraged from continuing with this field for his life work.

It may be of interest to cite some figures regarding the fruit growing business.[1] According to the 1940 U. S. Census, only 2.1 per cent of the farms in the United States are devoted principally to production of fruits and nuts. In comparison with other farms, the value of the land and buildings on these fruit farms is twice as great as on the average farm. The expenditure for labor in an orchard is nearly three times as much. Also, on the average there are more automobiles, motor trucks, and tractors on fruit farms. There are three times as many dwellings which are lighted with electricity and considerably more fruit farms with telephones. This analysis from the Census is an index of the cultural development of orchard folk. In fact, probably no one has a better vocation, a more delectable product, or more desirable associates than the American fruit grower. A good home with all modern conveniences, which sets his family off as a cultured, comfortable group, is fully in the picture of the future. Such a situation is inviting to forward-looking people who love rural life.

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[1] Deducted from the Census figures by the Research Department of the American Fruit Grower magazine in co-operation with the U. S. Dept. of Agr.

Review Questions

1. How has the general price level in the United States behaved, and how has it affected the fruit grower's income?
2. Considering present economic conditions, would you recommend a moderate expansion in fruit plantings?
3. How does the United States rank in world fruit production?
4. Briefly describe where the fruit regions of the United States are located, and what are the major fruits produced in these regions?
5. What is the leading fruit state in the United States, and how do you account for this?
6. List the five leading deciduous fruits grown in the United States.
7. In the past ten years, how does citrus production compare with the production of leading deciduous fruits?
8. What is the relative importance of the processing field in deciduous fruit growing?
9. Discuss briefly the apparent trends in fruit growing.

Suggested Collateral Readings

Anonymous. Johnny Appleseed, by one who knew him. F. J. Heer Printing Co., Columbus, Ohio. 1922.

Anonymous. A graphic summary of farm crops. U. S. Dept. of Agr. Misc. Pub. No. 512. February, 1943.

Anonymous. "Crop report for fruits," "The fruit situation," and other fruit crop data. U. S. Dept. of Agr. Bur. of Agr. Econ. Washington, D. C. (Issued several times a year).[1]

McCown, Monroe. U. S., the world's fruit basket. American Fruit Grower Magazine 68: No. 1. pp. 30, 34. 1948.

LaMont, T. E. and H. F. DeGraff. Making fruit farms pay. New York (Cornell) Ext. Serv. Bull. 554. 1943.

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[1] Fruit growers, teachers, and commercial distributors of fruit growing equipment and materials may be interested in having their names placed on the mailing list to receive these fruit crop data.

CHAPTER II

Establishing the Fruit Planting

LOCATING THE ENTERPRISE

It is a serious mistake to locate an orchard improperly. An error in planting annual crops can be corrected the following year, but with fruit trees it is a long-time proposition. Careful orchard planting at the beginning pays large dividends later. In the early 1900's during boom periods, orchards were indiscriminately planted, many on sites where climate and soil were not suited to fruit growing, and, as a result, these orchards proved unprofitable and sooner or later were abandoned. Today, commercial fruit growing is limited to definite regions which have proven over many years to be adapted to profitable fruit growing.

Before selecting a region for fruit growing, it is important to make a careful study of the transportation and marketing facilities, winter and spring temperatures, moisture, soil and site conditions, and suitability of a certain kind of fruit for a given region and site. There are many advantages in locating the fruit enterprise in a region where fruit growing is well established and where there are big centers of population. The advantages are as follows:

1. There are definite savings in co-operative purchasing of supplies and equipment on a large scale.
2. Repairs for machinery and general orchard supplies are readily available from near-by large dealers.
3. In well-established regions, there is considerable local interest and inspiration to be gained from intelligent and alert fellow workers.
4. A more stable market with efficient selling organizations where buyers of large quantities come regularly to fill their requirements.

5. Shipping charges to distant markets are usually not necessary.

6. Commercial storage space, processing plants for lower-grade fruits, and outlets for the by-products are likely to be favorable.

7. Broad and heavily traveled roads near large cities afford excellent sites for roadside fruit markets.

8. Transportation facilities in and out of the region, when needed, are usually adequate and rapid.

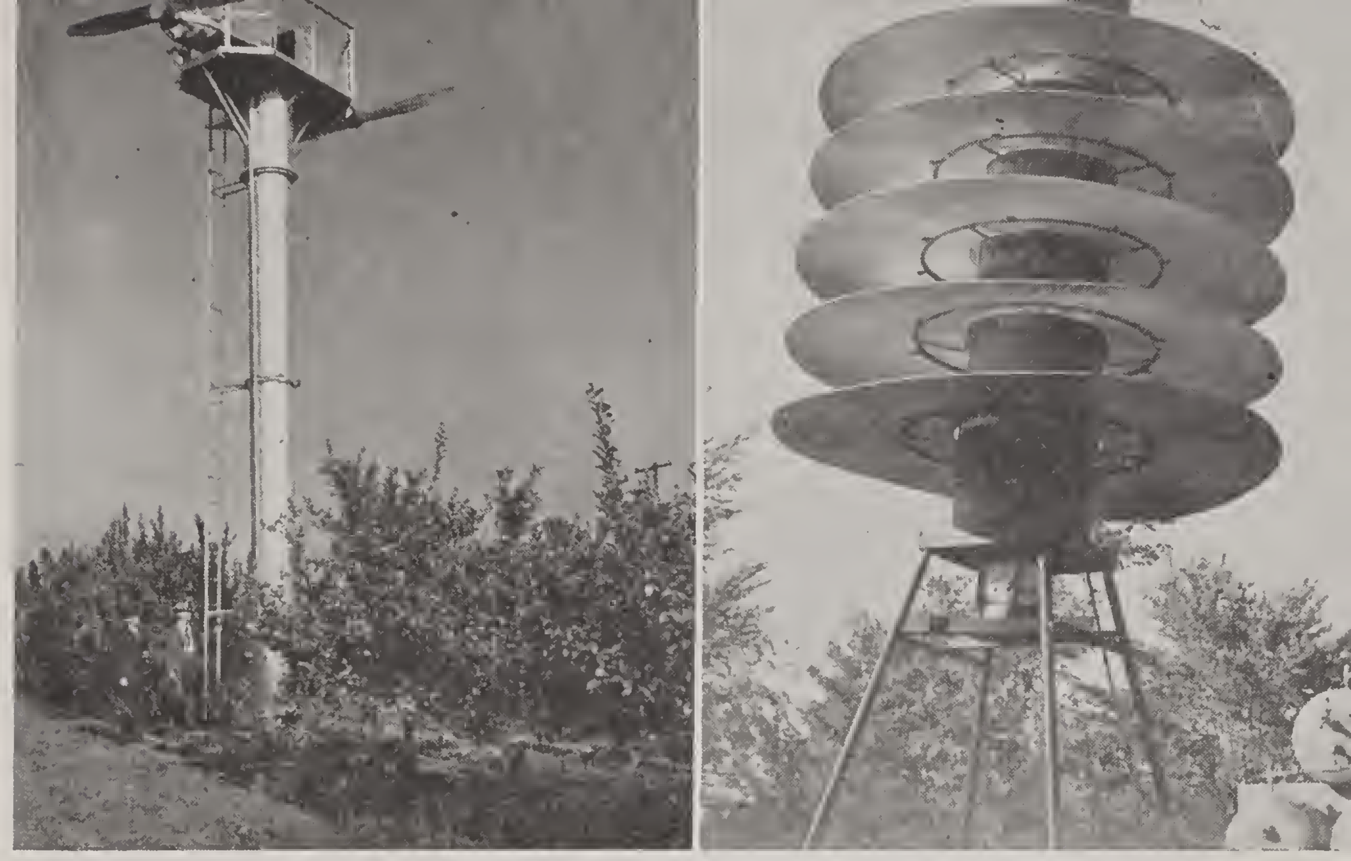
9. In general, there is better quality and more extensive public service from recognized agencies, such as the experimental stations, agricultural colleges, county agricultural agents, and large commercial firms dealing in orchard equipment and supplies.

10. In major fruit states, a greater percentage of a grower's tax money and investment in equipment come back to him in service from public agencies interested in fruit growing.

There will always be scattered orchards away from centers of population and fruit growing, and they have their definite advantages. Such growers usually manage smaller acreages and enjoy a more or less independent local market where fruit prices are often better than in heavily supplied general markets, provided the business is not overdone. Good fruit land in such areas is often less expensive to buy and carries less taxes, which makes for better profit in production. Furthermore, there is less danger from insect and disease contamination from neighboring unkept orchards, or from build-up in certain insect populations such as the codling moth.

Climatic factors. *Temperature* is the most important climatic factor affecting the geographic distribution of fruits and varieties of the fruits. Man has little control over temperature and, therefore, it is wise to check carefully with local growers, horticultural extension service specialists, and the local U. S. Weather Bureau regarding frequency of frosts and extreme temperatures in past years. An increase in altitude results in lower temperatures the same as a change in latitude from the equator northward. Extremely cold winters where the temperature falls to 20° or 40° below zero, or violent fluctuations from relatively warm temperatures in winter to extremely cold temperatures are not desirable for deciduous fruits. Such fruits succeed best with an uninterrupted period of winter rest when life processes are held at a minimum. Neither are long, hot, dry summers favorable to successful fruit growing.

Spring frosts or freezes shortly before, during, or after bloom constitute one of the most important hazards in fruit growing. They are far more destructive to the fruit industry than autumn frosts. The possibility of an occasional frost is a hazard on which many fruit growers take a chance regardless of how successful a given region may be in fruit production. It is hard to find orchards that do not suffer from them at one time or another. For example, the average peach grower in the midwestern states expects an average of one good crop of peaches in three years, with two entirely or par-



(Left) National Frost Protection Co., Inc., Glendale, Calif. (Right) V. R. Gardner, Michigan Exp. Sta.

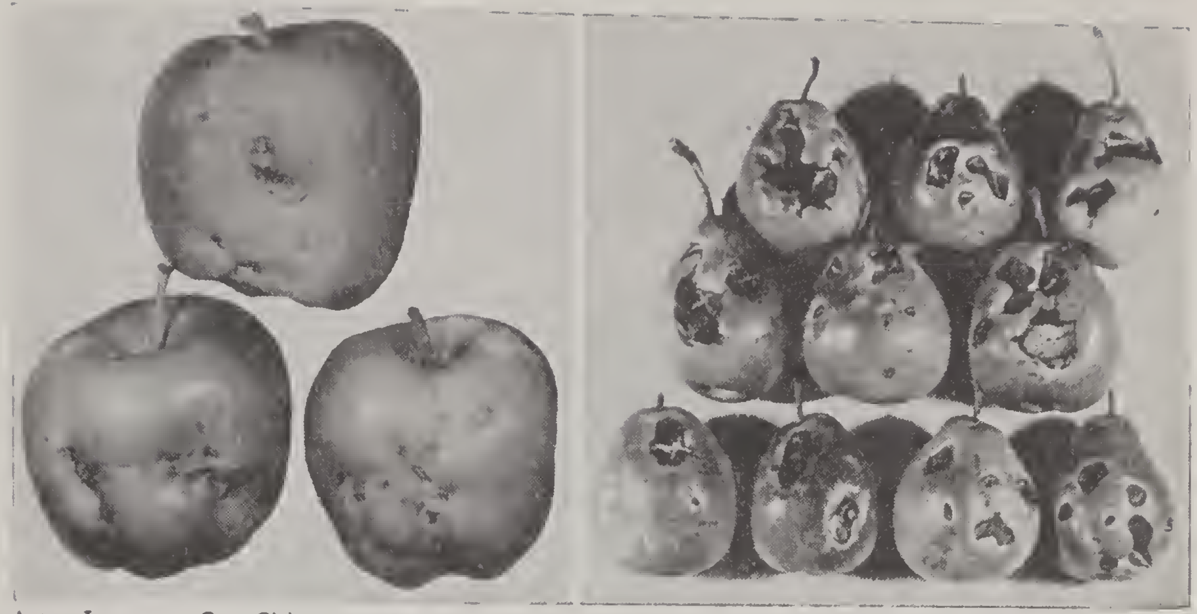
Figure 10. (Left) A California dual "Tropic Breeze" machine for drawing warmer air from above and spreading it over up to 20 acres of the orchard floor to prevent frost damage. Helicopters are serving a similar role. (Right) Economical oil burner with heat reflectors mounted on rubber-tired wheels. Top folds back toward oil tanks for road travel. Accommodates one acre at cost of 75 cents an hour, raising temperature about 8 degrees.

tially lost to spring frosts or winter freezes. It is not necessary to have a crop of peaches or sweet cherries every year in order to make the venture profitable. Injury from spring frosts are less likely near large bodies of water such as the Great Lakes which have a tempering effect, especially within a mile or two of the lakeshores. A slight tempering effect may extend back as far as five or ten miles, but this effect rarely makes the difference between a crop or no crop. There are three main advantages of near-by large bodies of water:

1. In spring, they keep the air temperature at a lower level and retard plant growth beyond the date of frost injury.
2. In autumn, they extend the period for ripening of fruit by maintaining a warmer air temperature near the shore line.
3. During the winter, they reduce violent and sudden fluctuations of temperature from warm to extremely cold.

Due largely to the tempering effects of the Great Lakes, the most concentrated fruit-growing regions in Ohio, Michigan, Pennsylvania, Wisconsin, New York, and Canada are located along the shores of these Lakes. Small ponds and shallow bodies of water have little or no tempering effect on the air temperature over surrounding land.

Heavy winds which blow more or less continuously over a site are definitely



Aetna Insurance Co., Chicago

Figure 11. A hail storm while the fruit is developing results in bruised, malformed fruit, most of which must be classified as culls. The trees also may be severely damaged. Sites where hail storms are known to frequently occur should be avoided.

undesirable. It is difficult to do a good job of spraying when the wind blows continuously from one direction. Dry winds during the blossoming period affect the fruit set and may result in frequent reductions in the apple crop. Also, there is a tendency for young trees to grow one-sided and lean with the prevailing wind. This more or less throws the tree off balance and may cause it to subsequently break over with a heavy crop.

Amount of *sunshine* is important in governing the rate of food manufacture by fruit-tree leaves which, in turn, affects the size and amount of color of apples and the regularity with which the tree bears from year to year. For example, in regions of Washington State where sunshine is relatively abundant, fruit production per acre is greater and alternate bearing of heavy and light crops of fruit is much less pronounced than in Eastern states where there is more cloudiness during the growing season,

Hail is a hazard in fruit growing which is less likely to be destructive than spring frosts. There are some areas in fruit growing regions, however, which experience hail more frequently than others. Local growers and hail insurance companies are probably better informed on the susceptible areas. Hail can be destructive to the fruit, reducing it in grade or almost destroying it completely if the stones are large. It shatters the leaves and is also destructive to the bark, bruising and splitting it, as well as stunting growth in general (Figure 11). Hail insurance for fruit is available and some growers, especially in regions of frequent hail occurrence, have found policies worthwhile.

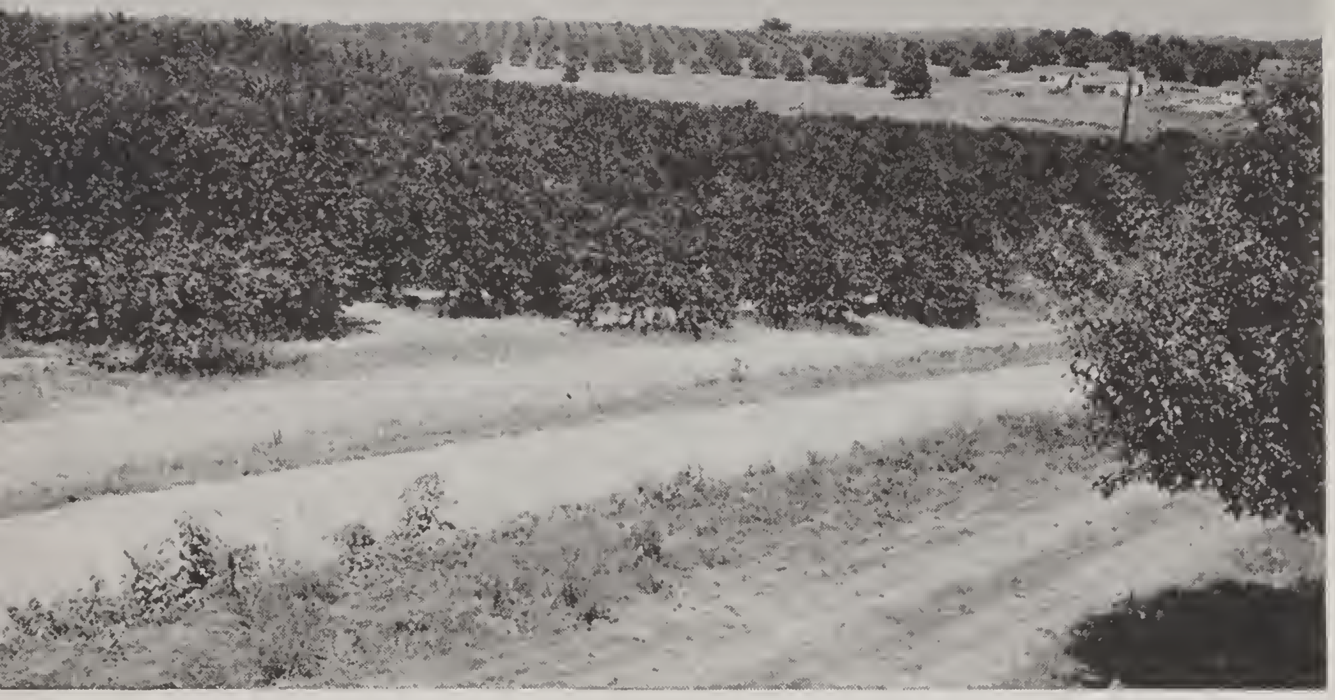
Size of planting. If the grower intends to serve a large and general market, he might consider a large enterprise of 100 to 200 acres or more. This will enable him to ship in carlots and thus receive greater consideration from large marketing agencies. If he intends to serve the local market, his business may be large or small, depending upon the size of the population to be served in the neighborhood. For example, near Cleveland, Ohio, one grower is managing 200 acres from which he sells almost his entire apple crop to the Cleveland trade. If the local market consists of scattered small towns, such a neighborhood usually will not absorb as large a quantity of fruit at a given time. However, it will purchase a continuous supply in small quantities throughout the consuming season. Grower-owned cold storages have made it possible for fruit growers away from concentrated population centers to give a small continuous supply of fruit to a limited local market.

The fact should not be overlooked that if the grower intends to grow solely tree crops, there is a period of five to ten years when the orchard will be largely an expense, and the trees will pay back little or nothing in fruit crops. During this period, he might consider diversifying his business by growing other crops such as small fruits or vegetables, and perhaps some livestock, such as poultry. Cultivation of small fruits or vegetables between trees, especially stone fruit trees, such as peaches, cherries, and plums, is particularly beneficial to the trees, as well as to the intercrop. The same equipment and facilities in general are required for both the tree and the intercrops and, therefore, the initial cost for equipment is no greater.

It is interesting to note that there is a definite tendency away from the small orchards of 10 to 20 acres. The profit from small orchards is usually not adequate support for an average-size family, and it is necessary for the operator to have outside interests. As a result, the orchard generally suffers from lack of proper attention. The grower must become a specialist in fruit growing and manage larger acreages in order to make the enterprise worthwhile and to justify use of modern mechanical equipment and housing.

Selection of site. It is important to select a good orchard site with favorable elevation. Upland rolling or sloping fields which are not too steep for efficient orchard operations are the most desirable sites (Figure 12). River bottoms or flat valley floors are definitely undesirable due to the fact that cold air settles in these areas and frost or freezing injury are frequent possibilities. It is necessary that cold air move out of the orchard into land and valleys located at a lower level. On a slope, trees should not be planted lower than about 50 feet above the base of the slope, especially where cold air drains slowly from the valley floor. Under such conditions, a difference of 100 feet in elevation may make a difference of 5° to 10° in the minimum temperature encountered. In some seasons, such differences would make the difference between a full crop and a crop failure. Level land is not objectionable if located within a mile or so from large bodies of water so that there is a tempering effect of the deep water.

Where there is a thick woods near by, it is dangerous to plant closer than within about 75 feet of it because the timber tends to harbor cold air. In addition, the forest trees compete with the fruit plants for light, water, and nutrients. Woods on a slope below an orchard may retard movement of



Ohio State University Agr. Ext. Serv.

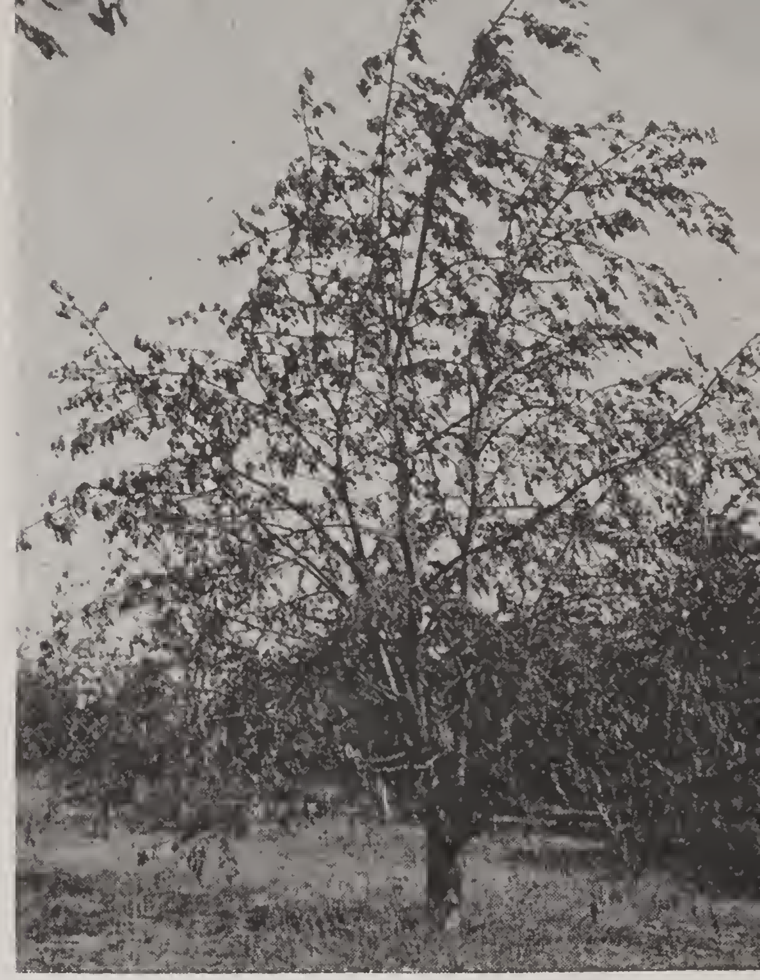
Figure 12. An excellent orchard site located near the heavily populated region of Columbus, Ohio. Peaches are shown in the foreground, apples in the background, with the residence, storage, and machinery sheds located in the center of the orchard next to a hard-surfaced road. Note rotation of different ages of trees in background.

cold air downward, but this can be remedied to some extent by cutting 75-foot swathes through the woods at 100-yard intervals.

Although it is desirable that the orchard be located on an elevated site in order to secure good air drainage, sites on top of ridges may be unsatisfactory because of exposure to winds, and generally drier and less fertile soil conditions. The direction of slope of the land usually has little effect upon the fruit crop. However, in case of persistent prevailing winds, an orchard planted on the leeward slope would naturally be the more desirable, especially if the winds continue during extremely cold weather. Such winds will increase freezing damage at a given temperature. It is true that north slopes tend to retard bud development in the spring, whereas south slopes accelerate it, and east and west slopes fall between in this respect. But there is little specific evidence on crop yields in favor of one slope over the other.

The location of an orchard on very steep slopes presents a number of problems in later management of the orchard. On steep hillsides, spraying was formerly a serious problem. However, this can be managed satisfactorily by installing a central stationary spray plant and piping the orchard for spraying. Cultivation of steep hillsides may be impractical because of the danger of erosion. It is fortunate, however, that the apple and pear will thrive well under permanent or semipermanent sod systems. Hence, if the soil is satisfactory, apple and pear orchards can be planted on slopes as steep as 20° to 30°, which is too steep for satisfactory growing of peaches, cherries, and plums. Many orchard operations, such as pruning and thinning, harvesting, and hauling fruit are more difficult on steep hillsides than on gentle slopes.

But the excellent air drainage usually found on such sites may more than compensate for problems in management.



Damon Boynton, Cornell University

Figure 13. The soil beneath this Schmidt sweet cherry tree is underlain with rock 18 inches below the surface. As a result of shallow rooting, the tree is shown dying during an extended drought. Fruit trees generally perform best with at least a four-foot rooting depth.

Selection of soil. The first requirement of a good orchard soil is proper water drainage which permits good aeration and extensive root development. The subsoil is probably more important than the upper layer of soil in growth and production of an orchard. When the subsoil is hard and impervious, trees may grow satisfactorily for a few years, but when the tops are large and producing fruit, they become weak, and if a dry year or a severe winter occurs, they may die (Figure 13). Fruit trees will not tolerate wet soils during the growing season. The roots can withstand some submergence during the winter dormant period, provided the water drains away by the time growth starts in the spring. Submergence of the root system for even a few days during the summer growing season, when temperatures are high, usually results in eventual death of the roots. Another period when waterlogging is disastrous is during the spring months when the buds are opening and the shoots developing.

A soil on which water stands for more than a week after a heavy rain is considered unfit for fruit growing. In most orchards, it is not unusual to find a wet spot here and there in depressed areas. These can be avoided, drained by tile, or made into ponds for water supply in spraying. There are instances where entire orchards have been drained by tile but such a practice is expensive. It is better to select land which does not need such preparation.

It is not a recommended practice to dynamite a hardpan to improve drainage and to create a greater rooting area. If the impervious hardpan is thin and underlain with well-drained sandy soil, dynamiting might prove satisfactory, but if the soil is relatively heavy throughout, the pressure of the explosion packs the soil in a bowl shape and further complicates drainage.

The rooting area for a fruit tree should be at least four to five feet in depth, but this depends somewhat on the region and soil type. Where rainfall is plentiful and well distributed over the growing season as in some sections of West Virginia, a soil three feet deep may be satisfactory for apples. In New York, fruit trees live longer and are more profitable on well-drained, even-textured, sandy or gravelly loam soils that permit root penetration to eight to nine feet than on heavy clay soils where root penetration is but three feet. In Nebraska where there is likelihood of long summer droughts and where deep loess soils are available, wider tree spacing in soils deeper than nine feet is being recommended. Generally speaking, about twice the rooting depth of soil is necessary in a medium sandy soil than would be necessary in a heavier silt loam soil to carry the trees through the same period of drought or the same interval between irrigations.

Level of the *ground water table* during the growing season, especially at blossoming time, is an important criterion of a good orchard soil. The soil is said to be unsatisfactory for orchard purposes if the water table remains within six inches or a foot of the soil surface for a week after a heavy spring rain, or within three feet of the surface for several weeks after growth starts. It is good practice to make a survey of the water table and drainage conditions previous to planting an orchard because some soils may be deceiving on the surface; also, the subsoil is known to vary considerably within a horizontal distance of 50 to 100 feet. The survey can be made by digging about four random holes per acre, using a post hole digger. The holes should be about four feet deep, into which a galvanized drain pipe or four-inch tiles are placed. The water table should be studied especially in April and May. In case of the better fruit soils, the ground water may exist within a few inches of the soil surface for an hour or so after heavy spring rains, but it falls rapidly and within a day or two, it drops to three or four feet below the surface. It is important that readings be taken at least at three-day intervals during spring months. In case of a poorly drained soil, the water table will remain a foot or two below the surface for a week or so after heavy rains.

Roots must have good aeration in order to function properly. This is the reason that drainage is so important. Under optimum rooting conditions in the soil, the pore space should be occupied 50 per cent with water and 50 per cent with air. Naturally, if the soil is poorly drained, the greater percentage of the pore space will consist of water. The inclusion of sand or gravel in an orchard soil tends to lighten it, enables it to absorb rain or irrigation water faster, gives it better drainage, and has a tendency to make it warm. Clay gives the soil body, but when it is present in considerable amounts, it makes the soil hard to work when wet and it cracks when dry. Presence of a certain amount of clay (20 to 40 per cent) is desirable because it contains available nutrient elements and assists in retaining moisture. Decaying vegetation and humus are also valuable in a soil because, they, too, help make nutrients available, greatly increase water penetration, and assist in giving the soil good tilth.

Fruit plants have a wide tolerance to soil reaction. Good apple orchards have been found thriving on soils from very acid (pH 4.0) to alkaline (pH 8.5; neutral is pH 7.0). Some pomologists have arbitrarily set the optimum soil pH at 5.6 to 6.6 because most intercrops and cover crops grow best in slightly acid soils. Also, laboratory research with potted fruit plants indicates that this pH range is most favorable.

Soil fertility from the standpoint of an orchard is not as important as the points discussed previously. Most soils in the United States, except the very sandy soils, are supplied with the necessary elements for tree growth, except for nitrogen. This can be added in the form of nitrogen fertilizers. Other elements which are occasionally lacking in soils, such as boron, potassium, and zinc, also can be supplied. Hence, the fertility of a soil is relatively less important than its physical characteristics and its location or site.

A criterion often used to pass preliminary judgment on the desirability of a soil for fruit growing is to observe the existing amount and type of plant growth. The soil shows orchard possibilities if it will grow a good crop of weeds and if the native trees are large and vigorous. Poor weed growth and trees showing weak growth with dieback in the tops is evidence of a tight soil with shallow rooting area.

The New York Agricultural Experiment Station and a few other experimental stations are giving valuable soil survey service by working through the county agricultural agents to assist fruit growers in choosing good orchard soils and sites. The orchard soil specialist from the experiment station goes by appointment to the prospective farm and makes a careful study of the soil and site, making specific recommendations to the grower. This is a service that all states might well initiate to avoid cases of financial loss and disappointment and to place the fruit growing business on a higher-profit level.

PLANTING PLANS

When to plant. Early spring planting as soon as the soil can be worked is generally the best time to plant in central and northern sections of the United States. When spring begins to break rapidly, a difference of two weeks in the date of planting often results in obviously better growth of the earlier planted trees. New roots will develop when the soil temperature is above 45° F., and if the trees are planted as soon as the frost is out of the ground, some root development will occur before the leaves appear. This early root development is highly important in getting the trees off to a vigorous start. Occasionally, there are periods of three or four weeks in spring when the weather is unduly dry. Many trees may be lost if planting has been delayed to the point where one of these dry periods follows shortly after planting. If such a condition unavoidably arises, it may be necessary to haul water to the field in a spray machine, or, in a large tank mounted on a truck. Although this is an added expense, it may make the difference between a 100 or a 50 per cent stand.

In the southern milder sections, if the temperature is not likely to fall below 0° F., trees may be planted any time the ground is not frozen in fall, winter, or early spring. However, it should be noted that the roots are more tender than the tops and may be killed by temperatures of 20° to 24° F. It is important, therefore, to consider this fact in shipping and handling trees during the winter months.

Fall planting in northern states can be done more successfully with apples, pears, sour cherries, and European varieties of plums than with peaches, sweet cherries, and Japanese varieties of plums. The advantages of fall planting are (1) frequently the soil is in better condition than in spring, (2) weather conditions are more favorable in late October or early November than in March and April, (3) there are usually fewer windy days, (4) nursery stock is less likely to become overheated in transit during the fall season, and (5) a fall-planted tree starts growth at the earliest possible time the following spring, usually earlier than spring-planted trees. In the South where peach trees are often planted in the fall, a common practice is to pile soil about the base of the tree in order to protect it during the winter period. It is important that the land be well drained when fall planting is practiced in order to prevent soil heaving during winter.

Varieties. The variety might be considered the keystone of American fruit growing. Probably more attention has been given to a consideration of varieties than to any other phase of fruit growing. In spite of the accumulation of much information on this subject, however, the selection of the proper varieties for a given location or condition remains a serious and difficult matter. Recommendations for varieties are given later under the heading of each fruit. The following suggestions are given for selection of varieties in general.

It would be well to study the market to be served to determine the varieties which are better known and bring higher prices. For example, on the New York market, McIntosh, Northern Spy, and Delicious almost invariably bring higher prices than York Imperial, Hubbardston, and Twenty Ounce. It is best for the grower to make a special attempt to satisfy the market demand for varieties rather than to try to educate the trade to accept his personal choice and opinions, even though they may be correct. It is usually easier to sell new and unknown varieties to the local market provided the grower has a good reputation for quality produce in the community. Red varieties, in general, are easier to sell than green or yellow varieties. Grimes Golden and Rhode Island Greening are examples of formerly leading commercial varieties which are meeting more resistance in sales in recent years. On the other hand, Cortland and Turley, and the red improved strains of several standard varieties of apples, as well as peaches, have been well received by the trade and give definite promise of being valuable additions to the commercial list.

Quality of the fruit is becoming of utmost importance in the final selection of a variety. It is too often true, however, that high-quality fruits have shortcomings which limit the extent to which they should be planted. These shortcomings may consist of susceptibility to disease, insect and cold injury, light or tardy bearing, short life, special soil requirements, uneven ripening, high proportion of low-grade fruit, fruit easily bruised, poor storage qualities, and others.

The varieties of a given fruit which grow best vary considerably with the region. One of the best guides in selecting the proper variety for a region is the experience of the commercial growers in the neighborhood. In most states, the agricultural experiment stations have been testing a wide variety of fruits for adaptability under local conditions, and, finally, the grower should check his variety planting list with his respective institution.

Cross-pollination. Some varieties of fruits will not set fruits when planted alone or with certain other varieties of the same fruit. It is important to match varieties in order that they may cross-fertilize. As a general statement, it is unwise to plant a single variety in a large plot. Plant two to four rows of a given variety and alternate with two to four rows of another variety with the same, or an overlapping blooming period. The pollinizer variety should not be further away than 80 to 85 feet, or two tree rows. Do not mix varieties in a row. It should not be overlooked that some varieties have poor pollen, or for other reasons are not good pollinizers, such as Winesap, Stayman Winesap, Baldwin, and Rhode Island Greening. In such cases, it is desirable to have more than two varieties interplanted in order to obtain an adequate set. For specific information on cross-pollination for a given fruit, see the chapter concerning that fruit.

Picking date. It is well to select about five good varieties of a fruit which ripen successively over a period of from one to three months, depending upon the kind of fruit. This facilitates many of the major orchard operations such as spraying, thinning, and especially picking and packing. The crews can spray, thin or pick continuously, shifting from one variety to the next as the trees successively bloom, the fruit increases in size, and ripens. It has been a common mistake to plant too many varieties; one should rarely plant more than ten.

Planting systems. There are several systems for planting an orchard and the selection will depend upon the topography of the land, kind and variety of fruit, the soil management practices, and if fillers are contemplated. Apple, pear, and quince will grow and produce satisfactorily in permanent or semipermanent sod. On the other hand, peaches, cherries, and plums are more satisfactory under a cultivation and cover-crop system. The sod system of management can be used in regions of the country where annual rainfall is greater than 35 inches. If rainfall is below 35 inches and irrigation is not readily available, some form of cultivation with or without cover crops will be necessary for moisture conservation for all tree fruits. Contour planting with or without terraces is one of the best systems adapted to cultivation management on rolling or sloping land. Planting systems which are better adapted to sod or semipermanent sod management are square, rectangular, triangular, and quincunx.

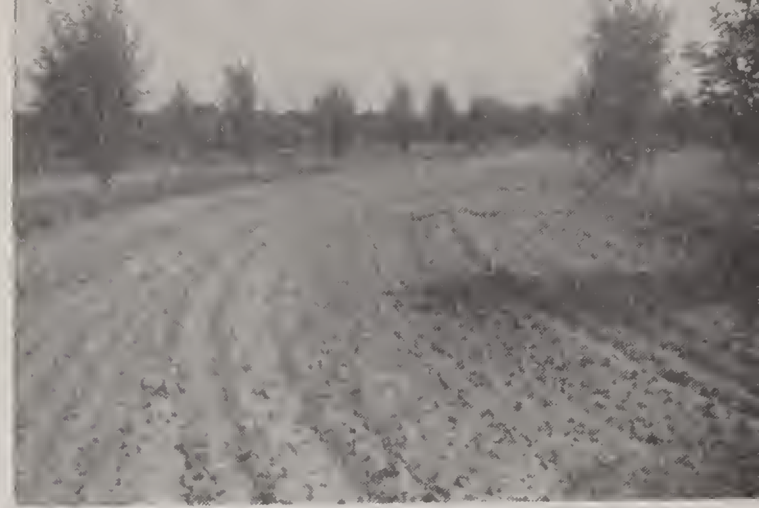
The *square* system is probably the most common planting method in which a tree stands in each corner of the square. The system is simple to lay out, adapted to the use of fillers or semipermanent trees, and the trees are easy to cultivate and spray. In the *rectangular* system, a tree is planted in each corner of a rectangle. In other words, the trees are further apart in one direction than they are in the other. This system is often used where intercrops such as strawberries or vegetables are to be grown between the trees for the first few years. If the land is sloping, the wider spacing should run across the slope, not up and down, as cultivation, hauling, and spraying up and down the slope will start erosion.

The *quincunx* system of planting is essentially the square system with a filler tree in the middle of the square. If the permanent trees are 40 feet apart with a filler in the center of the square, the filler will be 28¼ feet from each permanent tree. With this system, orchard operations may need to be performed on the diagonal until the filler trees are removed, which may be difficult when the land is sloping. If desirable, additional fillers can be made in one direction or both directions, making them 20 feet from the permanent trees.

In the *triangular* or hexagonal system, all trees are equidistant on the triangle. This plan allows for more equal distribution of tree tops and roots in a given area. About 15 per cent more trees can be planted per acre than in the square system, using the same planting distance. For example, if the trees are 40 by 40 feet in the square system, this permits 27 trees per acre, whereas with the triangular system, there will be 32 trees per acre with the same distance. The triangular system is somewhat more difficult to lay out than the square system and is not so well adapted to fillers.

Contour planting, or contour planting with *terraces,* is gaining favor rapidly. With stone fruits which require an abundant supply of moisture and respond well to cultivation, it is almost imperative that they be planted on the contour where slopes are involved. If definite drought periods are common in a region and irrigation is not readily feasible, it might be well, also, to use contour plantings with or without terraces for apple, pear, and quince (Figure 14). A certain amount of cultivation under these conditions, especially while the trees are young, may be essential to eliminate competition of the sod or intercrop with the trees during the critical dry periods. Such cultivation also will allow the soil to absorb more of the rainfall.

Contour planting with terraces has several important advantages. Soil and rain water are conserved, resulting in better growth and production of the tree over a longer period of time. The terrace channels are convenient for irrigation when necessary. There is more economical operation of orchard machinery on the more or less level contour runways, as compared with operating on the diagonal or up and down slopes. This greater ease of operating machinery is especially important to the fruit grower when he is trying to meet the spray schedule in spring or any other period when the ground is soft. One disadvantage is the difficulty of spraying at different angles of the wind. Also, it is difficult to cross the terraces with equipment when spraying, hauling fruit, and similar operations. Actually, however, in properly laid out contour plantings there is little need for crossing the terraces.



J. T. Bregger, U.S. Soil Conservation Service

Figure 14. An orchard planted on level contour lines showing low ridges or terraces along the tree rows which have been built up by contour cultivation. This practice is essential to conserve moisture in areas where the annual rainfall is less than 35 inches.

Planting distances. The proper distance for planting a given fruit has never been definitely settled. Distance of planting will depend upon the region, soil type, cultural care, and the variety to be grown. Fruit trees grow larger in some sections than in others. On a deep fertile soil in New England, a McIntosh tree may have a spread of 50 feet at maturity, whereas on a more shallow less fertile soil, it may occupy only 30 feet. Some varieties are naturally small and do not require as much space as other varieties. Small varieties are Wealthy, Jonathan, Yellow Transparent, Golden Delicious, and Wagener. Varieties which tend to grow larger are Stayman Winesap, McIntosh, York Imperial, and Baldwin. A Montmorency cherry needs more space than a Morello, a sweet cherry more than a sour. The following planting distances for orchard trees are suggested:

TABLE 2

PLANTING DISTANCES SUGGESTED FOR FRUIT TREES[1]

FRUIT	FEET	FRUIT	FEET
Apple	35-45	Dwarf trees	10-10
Pear	25-35		10-15
Plum	20-24		15-15
Peach	20-24	Nuts	
Apricot	20	Filberts	18
Cherry, sour	20-25	English Walnuts	40
Cherry, sweet	25-30	Black Walnuts	50
Quince	18-22	Hickory	40
		Pecans	50
		Chestnuts (Chinese)	40

The number of plants required to plant an acre may be determined by multiplying the distance they stand apart both ways and dividing the figure into the number of square feet in an acre (43,560).

Some commercial growers have used the square system of planting, initially spacing apples, for example, 25 feet apart. Within 15 to 20 years, when the trees begin to crowd, the diagonal rows are removed, leaving the remaining trees 35 feet apart. This is adequate spacing for moderately vigorous trees, such as Golden Delicious, Rome Beauty, and Winesap. On the other hand, vigorous trees planted 28 feet apart on the square would be 39.6 feet apart after the removal of the diagonal rows. If trees are originally planted 30 feet apart, the distance will be 42.4 feet after taking out diagonal rows, which is a desirable distance for strong growing varieties, such as McIntosh, Baldwin, and York Imperial on good soil. On most soils for apples, about 35 feet as a permanent distance should be most satisfactory for moderately vigorous varieties and 40 to 42 feet for the most vigorous ones.

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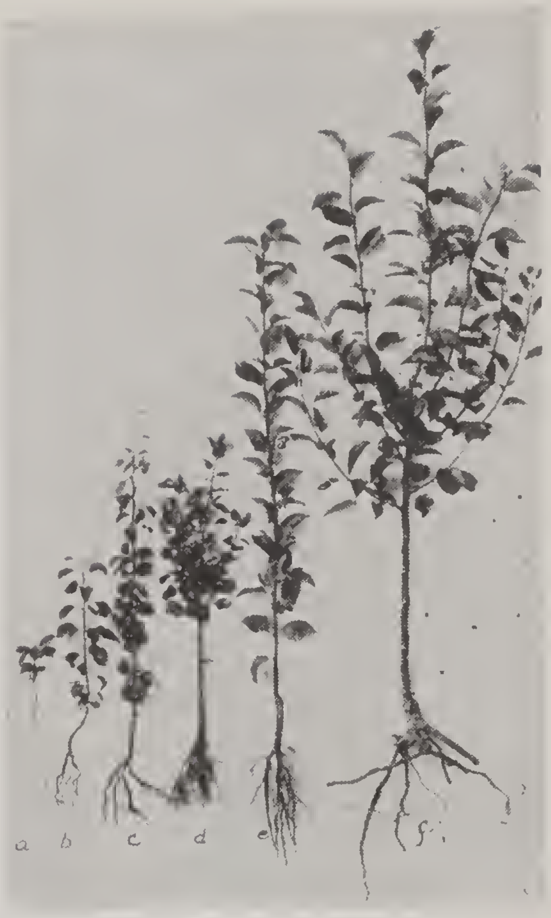
[1] Planting distance is greater with large-size varieties and with more favorable soil and climatic conditions.

The great danger in using filler trees is that growers tend to leave them too long in the orchard, and serious injury to the permanent trees from crowding occurs before thinning is done. Generally, filler trees can be left until about ten to twelve crops have been harvested, but, at the time of planting, the grower must face the fact that fillers must be removed when they begin to interfere with the permanent trees.

ORDERING AND CARE OF NURSERY STOCK

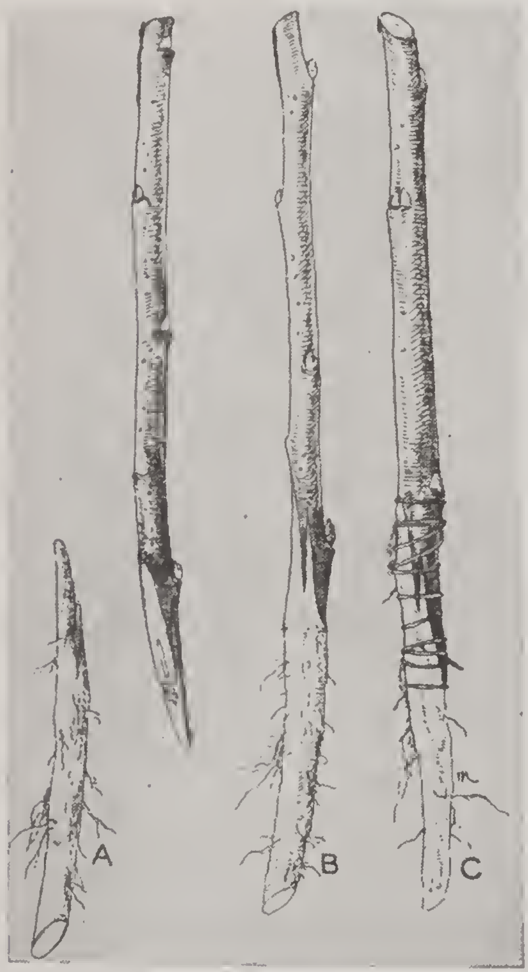
It is wise to plan the orchard at least eight months in advance of the planting time. For spring planting, this would mean that plans should be made during September and October and an order for the trees made not later than November. This insures punctual delivery of the better grade stock early the following spring. Usually, there is a terrific rush for fruit trees during March and April when the nurseries are so heavily laden with orders that it is impossible for them to get shipments out until late spring, which is much too late for successful orchard planting. Also, a nursery company often depletes its stock of certain varieties long before it fills its orders. Preference should be given to reliable local nurseries where transportation charges are less and adjustment for faulty stock easily can be made. Where possible, it is good business to make an advance personal selection of stock in the nursery row. It pays to buy the better grade larger plants of a given age. There is an increase demand for one-year whips of apple, pear, and certain other fruits for the following reasons: (1) The trees cost less than two-year trees; (2) Often the trees are inherently more vigorous; (3) Transportation charges are lower; (4) They withstand transplanting better; (5) They start growth sooner; (6) They cost less to plant because they are more easily handled and do not require as large a hole for the roots; and (7) The chief benefit is that the grower can train and select the side limbs on the whip according to his desires. In case of a two-year apple and pear tree, for example, the tree comes with its side branches already formed and it is necessary for the grower to eliminate the undesirable limbs; the remaining scaffold limbs are often not too desirable from the standpoint of their arrangement, angle of crotch, and other characteristics. Recent experience has been that a better scaffold system can be formed by deshooting one-year whips shortly after they start growth (see discussion on training young apple trees in Chapter IV). One-year and two-year nursery trees planted side by side cannot be distinguished in an orchard four or five years later, so far as their size is concerned.

Standard varieties of fruit do not come true to seed and, therefore, it is necessary to bud or graft the wood of desired varieties into seedling roots. As an example, with apples it is common practice for the nurseryman to plant seed of the French crab or certain standard American varieties in wooden flats and after a year transplant the seedlings to the field in spring. These seedlings may be (1) budded in the field to desired varieties the following July to September, cut back the next spring above the bud, and allowed to grow in the nursery a year for one-year trees and two years for two-year trees, or, (2) the seedlings may be dug in the fall and the roots cut into sections onto which shoots of desired varieties are whip-grafted (Figure 16). This is done indoors during the winter period, generally January and February, when



H. B. Tukey, Michigan Agr. Exp. Sta.

Figure 15. Stages in the development of a young pear tree. (a) French pear seedlings grown in a greenhouse flat; (*b*) after growing one year in seedling nursery row and just before digging in fall of 1931; (*c*) lining-out stack in spring of 1932 soon after planting; (*d*) at time of budding in August 1932; (e) 1-year tree with standard variety top, the fall of 1933; (*f*) 2-year tree, fall of 1934, ready for digging (after leaves drop) and planting to an orchard the spring of 1935, New York. Stages in the development of an apple tree are similar.



G. E. Yerkes, U.S.D.A.

Figure 16. Varieties of fruit trees do not come true to seed. During the dormant season, pieces of shoot wood are removed from the desired variety and whip-grafted on roots of seedlings of the same or a closely related fruit. Above system of propagation is commonly used for apples and pears.

work is slack. The grafts are then stored in the cellar in cool moist peat moss or sawdust until the following spring when they are set about 12 inches apart in nursery rows spaced three feet apart. After one season's growth in the nursery, they are cut back and allowed to grow another season, after which they are dug and sold in the spring as one-year trees. The age of a nursery tree refers to age of the top, not the roots.

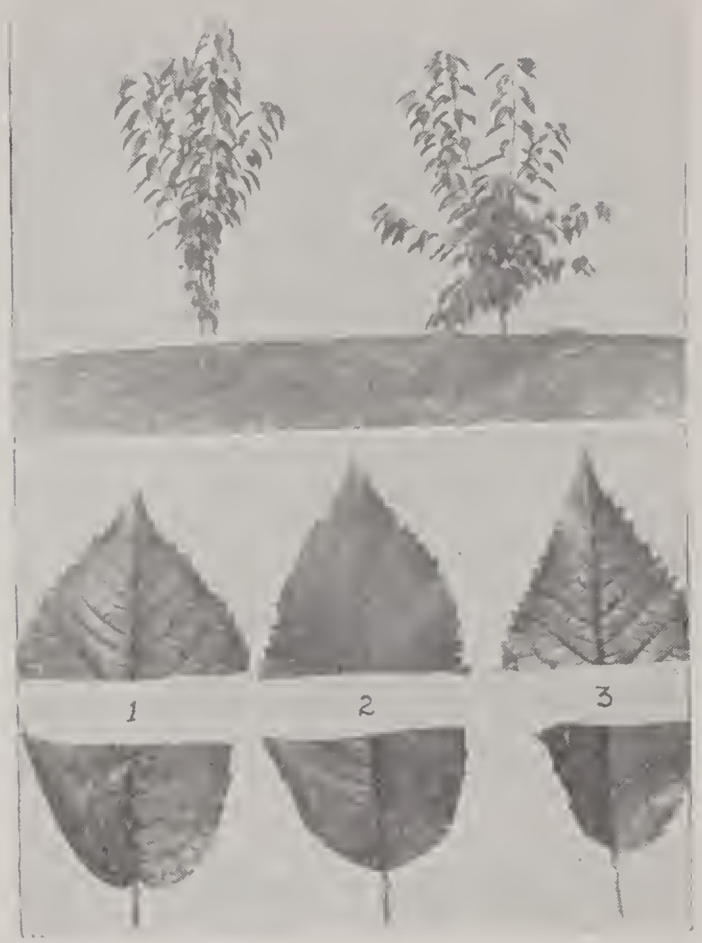
Where the growth is not sufficient to form large trees in one season, as is frequently the case in northern nurseries, these one-year trees are headed back and grown a second season in the nursery; these are referred to as two-year trees. Hence, the two-year trees are naturally larger and have thicker trunks than one-year trees, and the tops may have several branches. Of course, the extra year in the nursery involves additional cost to the nurseryman, as the so-called one-year budded trees represent one-year variety tops on three-year seedling roots, whereas the two-year budded trees represent two-year tops on four-year roots.

Piece-root grafting in apple and pear propagation, as described in Figure 16, is used instead of budding to a larger extent in the midwestern states and to a limited extent elsewhere. Advantages of this system are that in case of cold-resistant varieties, they have their grafted seedling roots which may be tender to cold, deeper in the soil and thus better protected from cold, as compared with budded stock. Often roots develop on the scion (upper piece of wood in Figure 16) which is a further advantage if it is cold-resistant.

Peaches, plums, cherries, and other stone fruits are budded on seedlings in the nursery in a manner similar to that for the apple. Seeds used for rootstocks for peaches are commonly obtained from native seedling trees in the region of South Carolina; for cherries, Mazzard seedlings are used; and for plums, Myrobalan seedlings. The seeds are layered in wet peat moss and given special temperature treatment during winter. In spring they are germinated and grown for a year in beds, then transplanted to the nursery row where they are budded to the desired varieties in July or August. The following March, they are cut back a few inches above the bud, grown for a year in the nursery and sold as one-year trees. Plums and cherries may be left for another year and sold as two-year branched trees, but peaches are sold almost entirely as one-year trees. Some so-called "June-budded" peach trees are sold, but these trees are small and a grower probably loses a year by planting them. They are budded in June in the nursery instead of August, and dug and sold the following spring.

Double-worked trees. This means that the tree consists of wood from three different varieties; for example, with apple the root may be French Crab, the trunk Virginia Crab, and the top Grimes Golden. In other words, the tree has been grafted twice, or double-worked. The reason for this is the fact that Grimes Golden and certain other tender varieties are susceptible to cold injury at the ground surface and in the lower main crotches. Inasmuch as Virginia Crab is relatively resistant to cold, it is inserted as an intermediate stock. Hibernal is used for the same purpose, and such trees are giving promising results with certain variety combinations. The commercial growers may buy from the nursery the Hibernal or Virginia Crab trees on French Crab roots, and after a year in the orchard, graft the desired varieties on them.

Certified trees. Most nurseries sell certified trees which means that the trees have been checked and identified by state inspectors as true to name. This is valuable service to the customer because it protects him against planting undesirable varieties. The inspectors are able to identify given varieties of trees by the leaf, bark, and general growth characteristics of the tree. For example, in leaf identification alone, there are many characters used such as: color, thickness, hairiness, size, vein network, shape of the leaf tip and base, waviness, folding, type of "teeth" at the margins of the leaf, the thickness and length of the leaf stem or petiole and the angle with which it is attached to the shoot. References to detailed work on this subject are given in the bibliography in case the student would care to make further study of this problem.



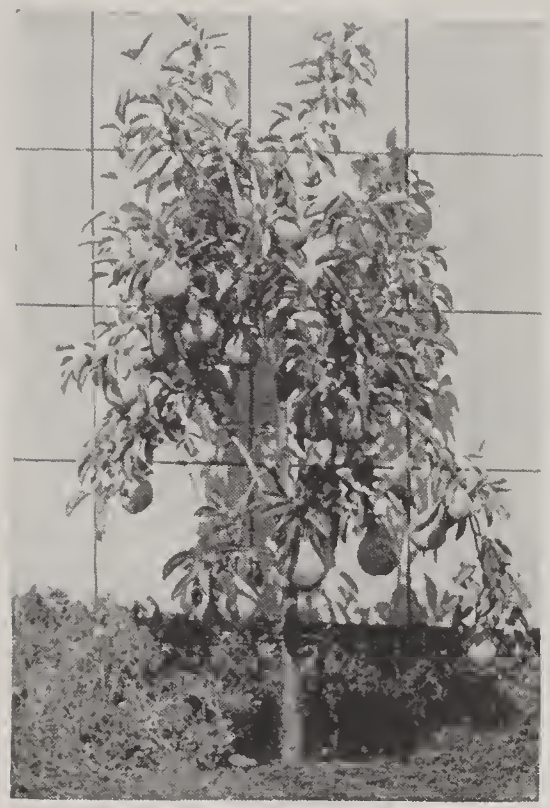
A. F. French, Massachusetts State College

Figure 17. Young and mature fruit trees can be identified by type of growth, leaf and bark characteristics, glands on leaf petioles, and other factors. (Top) The difference is shown between growth of Black Tartarian sweet cherry at the left and a Napoleon cherry at the right. (Bottom) This shows the differences between outline, teeth, texture, and other factors of the apexes and bases of six sweet cherry varieties. Leaf apexes are (1) Lambert, (2) Napoleon, and (3) Ida. Leaf bases are (1) Windsor, (2) Giant, and (3) Gold.

Pedigreed trees or bud-selected stock means that the nurseryman has selected buds or scion wood from special highly colored or "high-yielding strains." Such "strains" may be trees that are growing on particularly fertile or well-drained soil, or that might have been growing on seedling stocks that were especially congenial. Thus, the more desirable characteristics of such trees are due to environmental influences and not to characters inherent in the scion wood from the tree. Pedigreed trees, therefore, do not have the virtues implied by the name.

Bud sports. On a named variety of tree in the orchard, occasionally a spur, limb, or larger portion of the tree may show a distinct variation in the fruit it produces as compared with the rest of the tree. These are known as bud sports and can be perpetuated by grafting the wood of this limb upon desired stocks or roots. A good example of a bud sport is the Gallia Beauty which is the red sport of the ordinary strain of Rome Beauty. Other well-known sports are the Starking, Richared, Jonared, Blaxstayman, Callia Beauty, Scarlet Staymared, and Blackjon. It is well for the orchardist to be on continual lookout for these improved bud mutations in his own orchard.

Not all varieties are obtained from bud variations. Some are developed by scientific breeding to obtain new varieties superior to the parents. Examples of varieties which have been developed by breeding programs are the Cortland apple, Fredonia grape, and the Halehaven peach.



F. S. Howlett, Ohio Agr. Exp. Sta.

Figure 18. A dwarf Bartlett pear tree bearing about a peck of full-size pears. The tree is 7 years old. Background shows square feet.

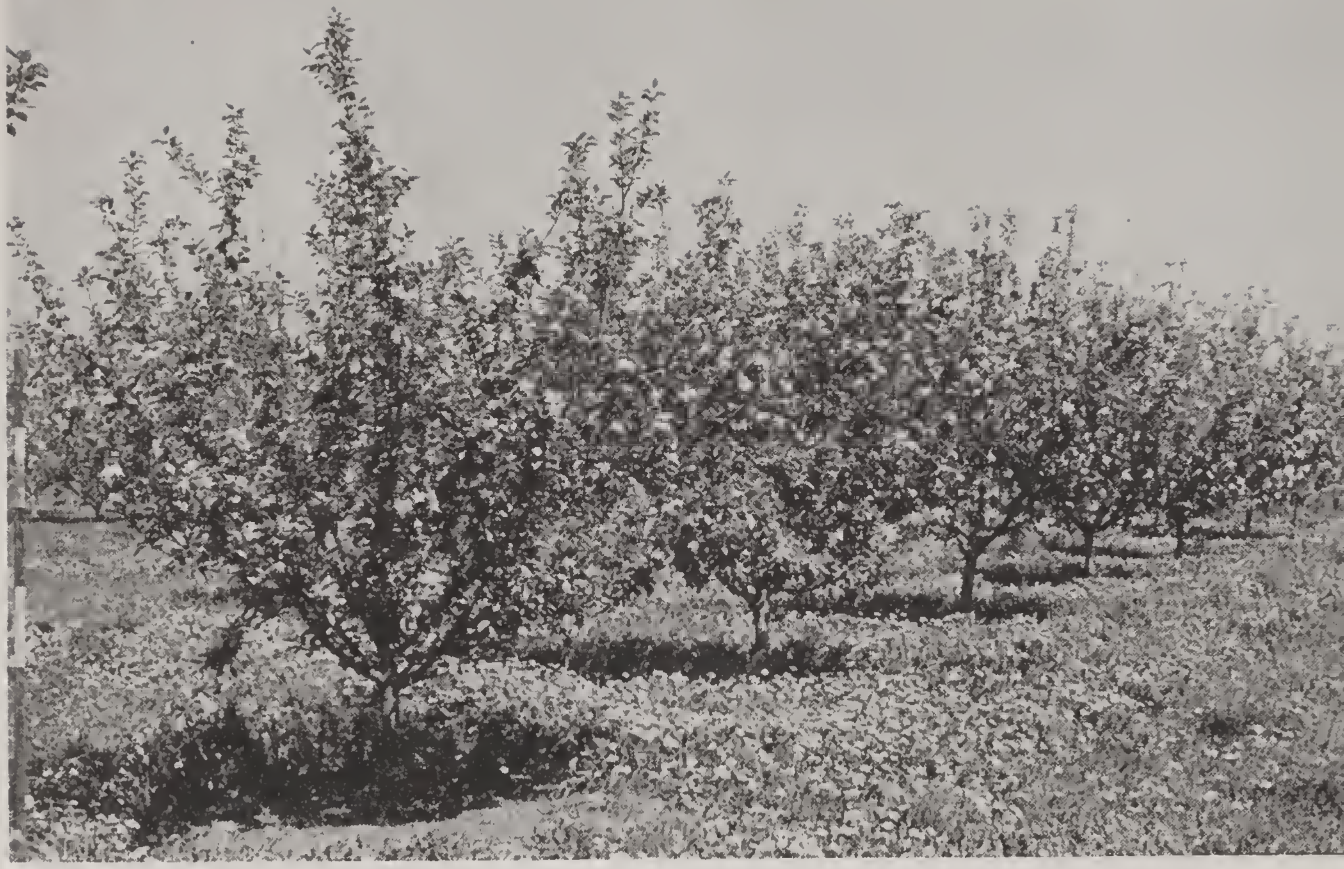
Dwarf and semidwarf trees. Thus far, dwarf trees have been recommended and used primarily in the home orchards (Figure 18). The advantages are that they come into bearing within two to three years, can be planted closely, are easy to spray and prune and can be trained to various designs against walls and along fences.

The difficulty with dwarf trees, however, is that they are shallow-rooted and may heave with freezing and thawing; they can be blown over easily by heavy winds and must be staked.

In recent years, there has been considerable interest in securing a uniform semidwarf commercial tree which is smaller at maturity than trees grown on French Crab seedling roots. Such trees could be planted closer with better utilization of the ground; also, the smaller trees are easier to spray, thin, pick, and prune. In case of apples, special interest has developed in the Malling stocks, certain of which tend to be semidwarf for specific varieties of apples (Figure 19). Considerable research needs to be done to study the effects of the various Malling stocks on different varieties of apples and under different soil and climatic conditions. At present, these stocks are being used but little commercially, but they are showing considerable promise and should be watched closely. The Angers quince root is often used for dwarfing varieties of pears.

Tree specifications. In ordering nursery stock, the following specifications are suggested for the different fruits:

Standard apple and pear varieties. Vigorous four- to seven-foot one-year trees (unbranched), or five- to seven-foot two-year trees about three-fourths-



H. B. Tukey, Michigan Agr. Exp. Sta.

Figure 19. Baldwin trees, 6-years-old, growing on semidwarfing Malling I rootstocks at New York Agricultural Experiment Station. Note uniformity of growth and good tree character. Semidwarf apple trees are easy and economical to manage.

inch in diameter near the base and well-branched. For pear varieties susceptible to blight, request Old Home blight resistant understocks (see pear propagation and rootstocks, page 256).

Dwarf trees. Two-year trees which are well branched and have relatively vigorous root systems.

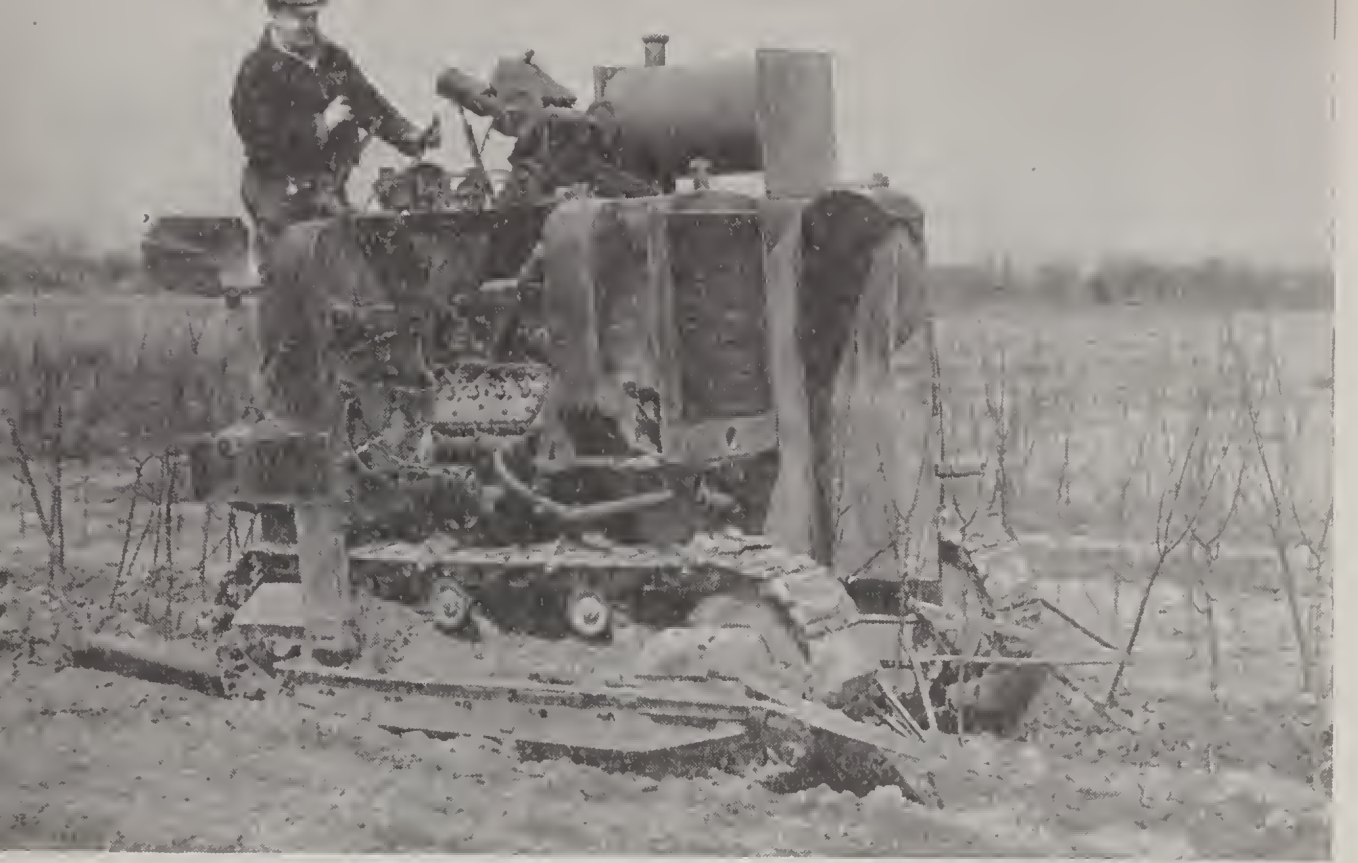
Cherries (sour). Sturdy one-year trees four to five feet high, or two-year branched trees, four to six feet, with diameter of five-eighths-inch or more.

Cherries (sweet). Select trees budded on Mazzard rootstock. Sturdy one-year whips, four to five feet; or, two-year trees of five to seven feet and diameter of about three-fourths inch.

Nuts. One- or two-year grafted stocks, large size. If the tap root has been severed about 18 inches below the ground a year before transplanting, more vigorous roots will have developed, which is desirable. Some nurserymen perform this root pruning as standard practice for nuts. Trees which are shipped with a ball of earth about the roots are more likely to succeed in transplanting.

Peaches, apricots, nectarines. Vigorous three- to four-foot yearling trees of one-half-inch diameter or more. Avoid large older trees or small one-year weak trees.

Plums. Vigorous one-year whips, four to six feet, or two-year branched trees four to five feet high.



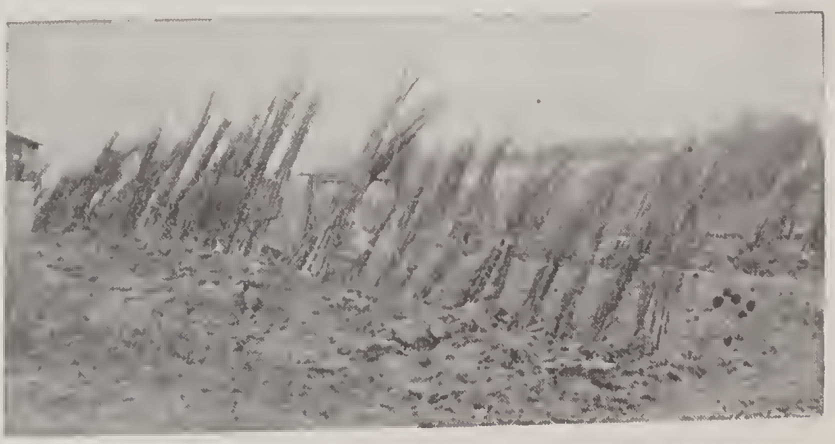
I. E. Ilgenfritz' Sons Co., Monroe, Mich.

Figure 20. Photo shows 2-year apple trees cut back a year previously to two feet above the ground; note side branches that developed. Trees are being dug by special nursery tree digger. This equipment explains in part why millions of dollars are invested in the nursery business alone.

Quince. Request two-year trees, four to five feet high, with a trunk diameter of one-half-inch or more.

Ordinarily, it is not wise to buy nursery trees older than two years. They are either so large that the shock of transplanting is too great, or, they are inherently slow-growing and ultimately will be relatively small and weak.

When the nursery stock is opened and separated, all varieties should be checked as to number, variety and grade, and those trees rejected which show crown gall, severe aphid injury on the roots, or winter killing as indicated by brittleness of wood and discoloration of the inner tissues. If the nursery stock arrives before it is convenient to plant, the bundles should be opened immediately and the plants heeled-in on a well-drained cool spot located, if feasible, on the north side of a building (Figure 21). Separate the trees, remove excess



Ohio State University Agr. Ext. Serv.

Figure 21. As soon as trees arrive from the nursery, they should be heeled-in firmly on well-drained soil and leaned toward the southwest.

peat moss or sawdust, and line them out in a furrow deep enough to accommodate the roots. Pack the soil firmly about the roots in order to avoid air pockets.

As soon as the soil can be worked, the plants should be set permanently, as early in the spring as possible.

If the ground is prepared and ready for planting when the trees arrive, they should be planted within 48 hours. During these 48 hours, they should be stored in the cellar, basement, or a cool damp place, wetted, and covered with a blanket of straw or gunny sacks.

PLANTING THE TREES

Preparation of the soil. Wherever possible, it is desirable to plant fruit trees in tilled land, regardless of the type of soil management followed later. If the land has been in sod, fall plowing is preferable in order to permit the soil to settle and the sod to partly disintegrate during the winter period. If the land is plowed in spring, it should be done as early as possible so that the ground can settle and absorb a plentiful supply of rainfall. The trees will need this moisture.

Staking the field. Building laths cut in half and sharpened on one end make satisfactory stakes. Where the land is rolling, full lengths of the lath can be nailed together to give greater height in low places. Tips of the stakes can be seen at greater distances and in hollows by dipping the ends in whitewash or by wrapping a white cloth around the tops. If timber poles are used, the bark can be peeled off the tops to expose the light colored sapwood.

Figure 22 shows a system for locating trees in a field by the square system of planting. In this case, the permanent trees are to be planted 40 by 40 feet with 30 feet between the fence and the ends of the rows in order to permit adequate space for turning with tractors and other machinery. It is important that all stakes be laid out in straight lines so that later the orchard will have a pleasing appearance from the road and will be readily accessible by machinery.

The first operation in staking is to select a base line which may be a fence or roadway along one side of the field. With a metal tapeline (cloth line may stretch), measure out 30 feet from the base line at several points along the base line. By sighting along these stakes, it is possible to stake the trees at 40-foot intervals along this line. Right angles can be determined at either end of this first row by using a carpenter's square to construct a large right triangle made from wood strips 20 to 30 feet in length on the short sides. One side of the square is brought in line with the base, and by sighting along the other edge of the square, a stake can be set, establishing a line or row at right angles to the base line (See Figure 22 for another method of obtaining right angles at corners). With one man sighting through this stake and the corner stake, and two men staking and measuring the tree distances,

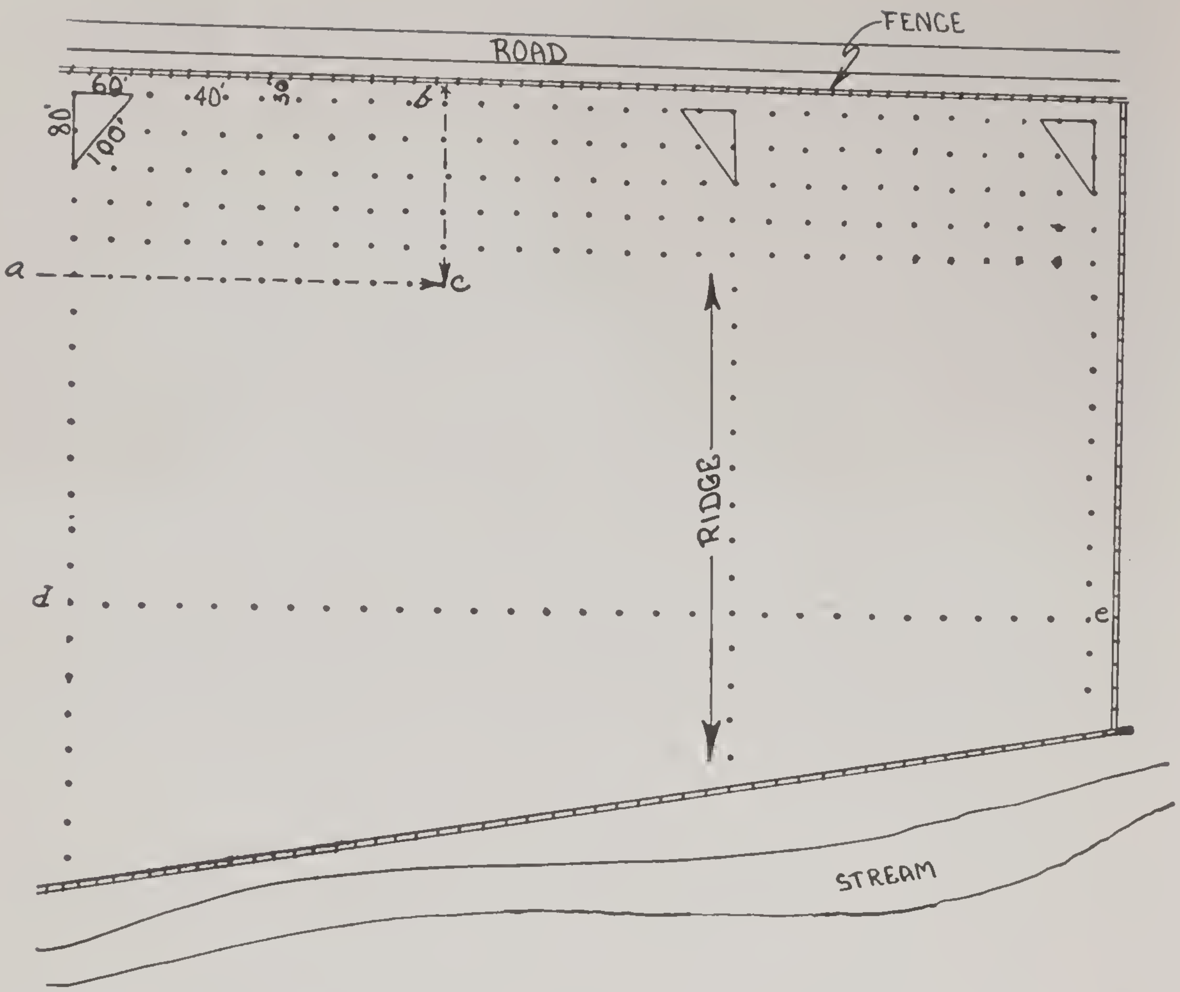
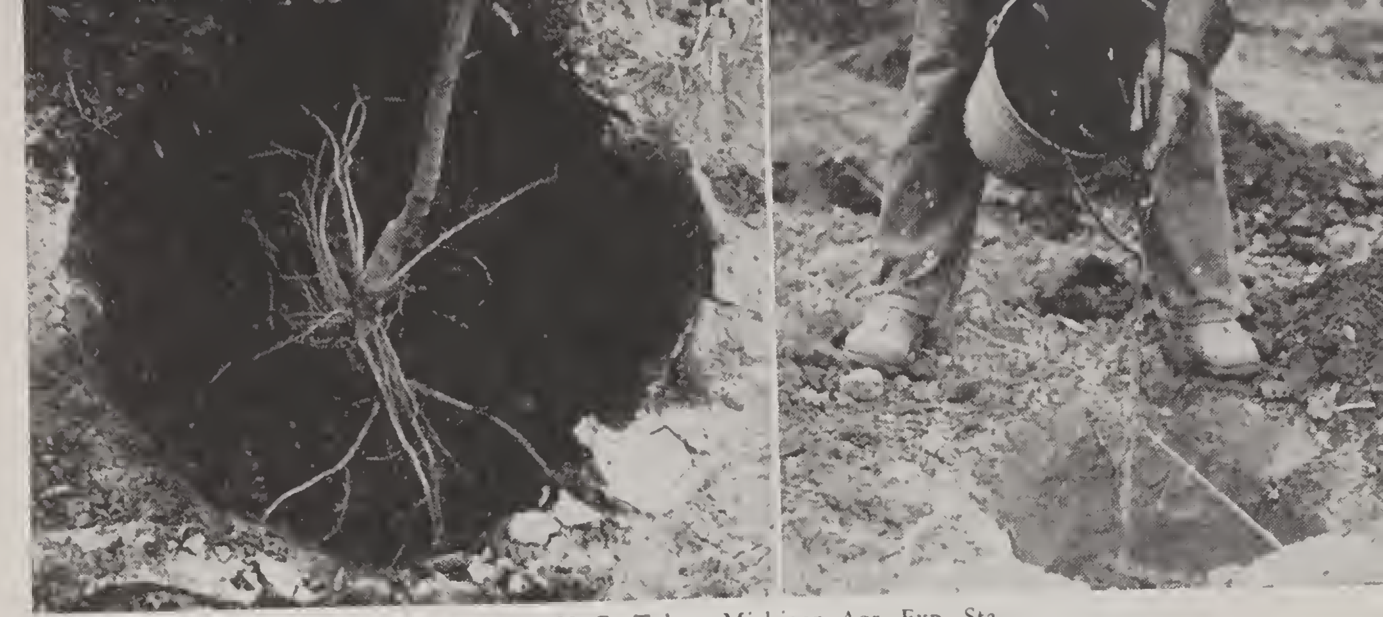


Figure 22. Suggested method for staking the orchard before planting, using the square system. Upper fence is the base line. Trees are 40 feet apart and 30 feet from fences. Right triangles are described at ends of first row to set outer left and right rows. (Metal measuring tape and stakes are used to lay out triangles.) Also, a row is established in center of field along a ridge for the man at *a* to sight upon. He cannot see row at extreme right. The line *d-e* was made for man at *b* to sight upon. Men at *a* and *b* are sighting while man at *c* sets stakes.

it is possible to lay out the second line. The square is then moved to the other end of the base line. This system is repeated until stakes are set for the third line. The fourth line is set similarly. In case the ground is very uneven, it may be advisable to set rows of stakes through the orchard in both directions at distances that can be readily seen for the balance of the staking. From this point, three men will be required to set the remainder of the stakes. One sights in one direction, another in the other direction, while the third man sets the stakes as signaled by the men sighting.

In case the triangular system of planting is employed, it is wise to use a large triangle made of heavy wire or chain with a ring in each corner. The sides of the triangle should be exactly the length of the planting distance desired. The base line is established as described previously and two of the rings are placed over two stakes in the base line while the third stake is placed in the third ring to form the second row. Each new complete row is used as a base line for setting stakes in the next row, and so on until the entire field is staked.

In southern sections, a team of horses is sometimes used dragging a chain



(Left) Ohio State University Agr. Ext. Serv. H. B. Tukey, Michigan Agr. Exp. Sta.

Figure 23. (Left) The hole should be large enough to accommodate the root system. Cut back broken and long roots; set tree as deep as it grew in the nursery. (Right) In heavier soils, better tree growth is obtained if a three-gallon pail of wet peat moss is mixed with the soil as it is sifted about the roots. Lift and lower the tree slightly while filling the hole; tamp soil thoroughly as roots are covered.

to mark off the tree rows. For this system, the outer border of stakes are first set and if the ground is uneven, the necessary inner stakes are set to locate the rows in low areas. By sighting between the team at the key stakes, a fairly straight line can be layed out. The team is driven in both directions and the trees are set where the chain marks cross.

Planting the trees. During the planting operation, 50-gallon drums one-third full of water are convenient for keeping roots of trees moist while planting. The drums can be transported on small trucks or wagons. An armful of the trees are usually removed at a time by the planters and kept wrapped in moist gunny sacks or canvas. The roots must be kept continually moist for best results. If the trees are dropped ahead of the planters, cover the roots with soil for protection until the planting gang arrives. It is important to locate each tree directly on the spot where the stake stood so that all rows will be straight.

It is desirable to dig a hole somewhat deeper and larger than necessary to properly accommodate the root system (Figure 23). Any broken or injured roots should be trimmed, but in general the root system should not be reduced more than necessary prior to planting. The roots of nursery trees contain stored nitrogen and other elements which are used in forming both new root growth and new top growth. In general, the tree should be set at approximately the same depth that it grew in the nursery. This "ground" line is usually visible on the trunk. Trees should not be set too deep, especially in the heavier soils. In very dry or sandy loam soils, however, it may be desirable to set the trees slightly deeper than they grew in the nursery in order to have the roots in contact with the moist soil. The lowest main limb should be placed toward the prevailing wind and the tree leaned slightly in that direction.

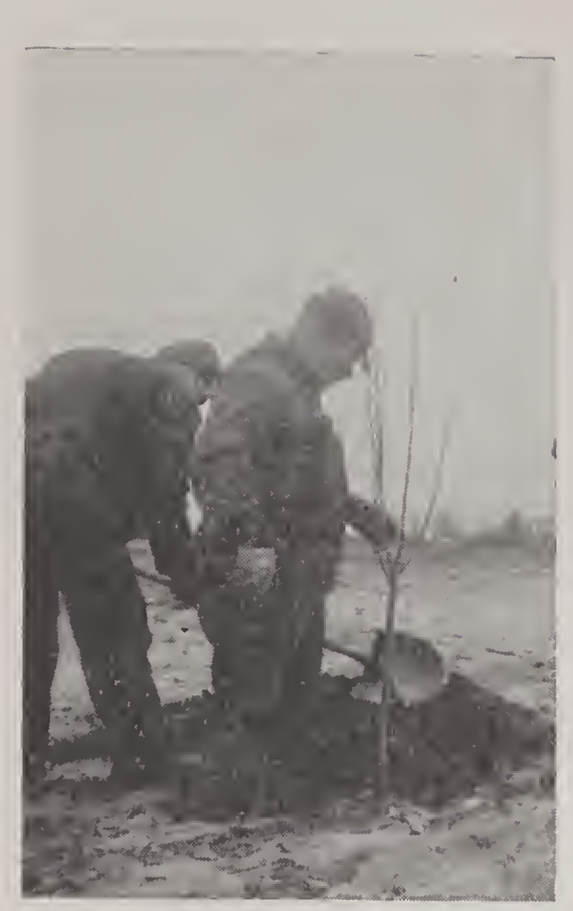


Figure 24. After the tree has been sighted in place, tamp the soil solidly about the roots with topsoil replaced first and subsoil last. Tree is leaned slightly toward the prevailing wind.

Usually the topsoil is more fertile than the subsoil and it is recommended that this layer of soil be set aside in a separate pile and later placed in the bottom of the hole while setting the trees. In heavier soils, better root development and better growth have been obtained when water-soaked peat moss is mixed with the soil surrounding the roots, as shown in Figure 23.

The tree should be set as firmly as possible. If it is difficult or impossible to pull the tree up by one hand after it is set, this is a good indication that the job is well done. One man using a garden shovel, as shown in Figure 24, can pour the soil into the hole while the other holds the tree in position and tamps the soil. In case of budded peach trees, there is a crook at the ground surface which should be located toward the prevailing wind.

After the tree is set, place about one-fourth pound of ammonium sulfate or its equivalent in commercial fertilizer in a circle on the soil surface about six inches from the trunk. Do not place fertilizer or manure in the hole next to the roots. Burning may result.

The newly set trees must be pruned shortly after planting. This is described in subsequent chapters for each fruit.

Contour planting. In contour planting on sloping land, all trees in any one row are in the soil at the same elevation. With this planting system, cultivation is done on the contour between the rows and not up and down the hill. Thus, cultivation tends to build up slight ridges or natural low terraces at the tree row which reduces the tendency of the water to run down the slope and increases absorption into the soil. Obviously, the tree rows will not be equally spaced in all parts of the orchard. On the steeper slopes, the rows will be somewhat closer together; whereas on less steep areas, they will be further apart. In some places, a given row may be so far from another row that it is possible to insert what is known as a "spur" row as shown in Figure 26. On steeper parts of the orchard, it may be necessary to discontinue parts of rows in order to prevent the trees from becoming too close together.

The first step in laying out a contour planting is to decide upon the minimum allowable interval between rows. This minimum difference will vary with the different kinds and varieties of fruit trees. For example, it is usually

15 to 18 feet for peach trees and 25 to 30 feet for apple trees. It differs, also, according to site conditions and to the individual preference of fruit growers. The first contour line should be laid out at the highest elevation. From a given point, the line is projected on the contour in both directions by using an engineer's level and rod. The line is projected to the limits of the area to be planted. It can be marked with lath stakes at 25- or 50-foot-interval stations. The next step is to proceed to the steepest slope in the orchard below the first line and establish a point at the minimum distance between rows below the first line. Thence, with the engineer's level, another line is projected from left to right. Whenever the distance between two adjacent lines becomes twice the minimum interval, a new line is laid out on the contour between them.

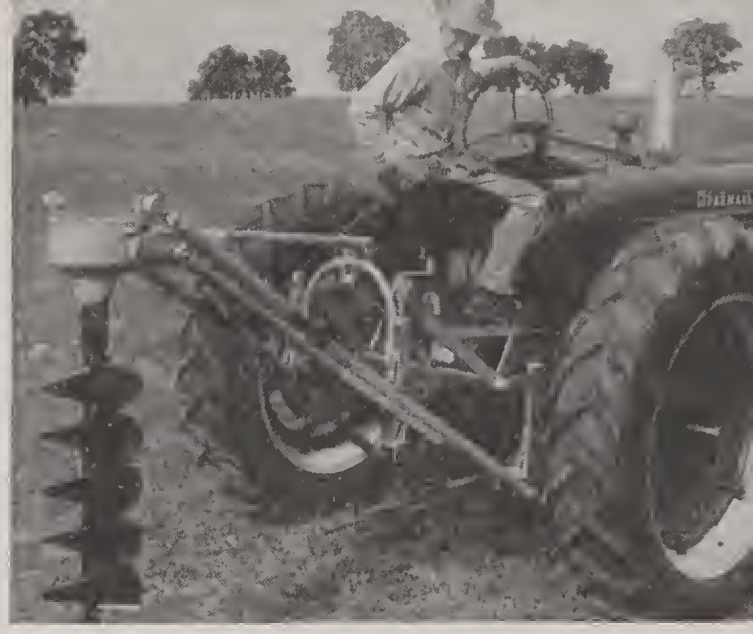
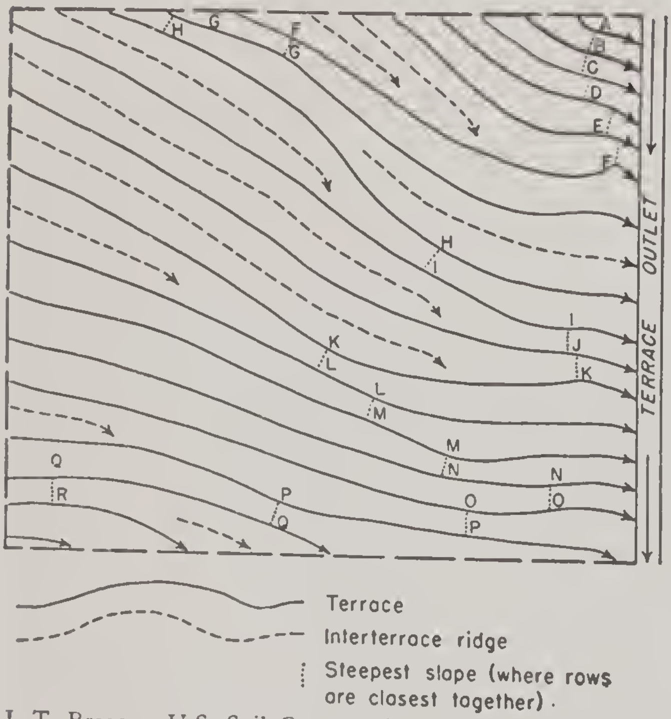

Paul Garner, Danuser Machine Co., Fulton, Mo.

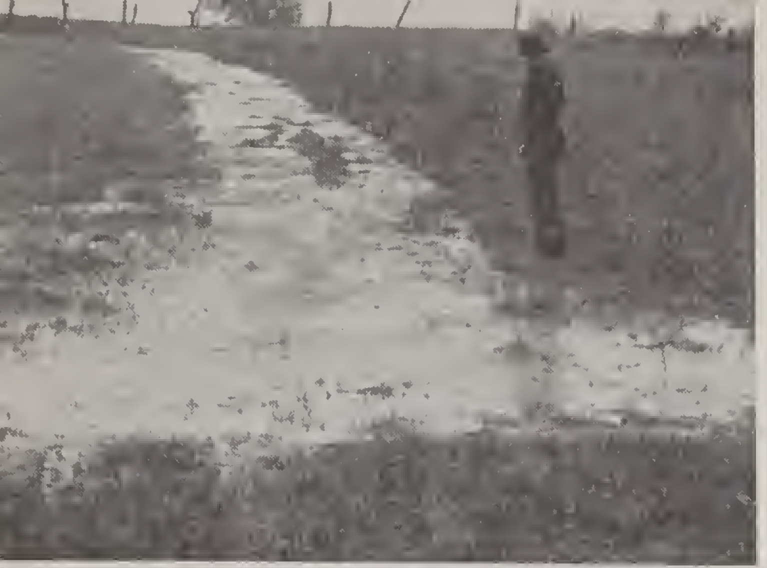
Figure 25. A digger attachment for tractors saves time in planting an orchard, digging post holes, or similar jobs. From 500 to 600 holes can be dug in a day, ranging in diameter from 4 to 18 inches according to bit size.

On the average, the interval between contour rows of trees is somewhat greater than that between rows of trees planted by the square system. Therefore, it is desirable that the average distance between trees in a row be somewhat less than the average space between the rows in order that the number of trees per acre may not be significantly less than if the planting had been done on the square. Where two rows come close together on the steep slope, the trees can be set somewhat farther apart in the row and staggered so that the machinery can more or less zigzag between the trees. In some orchards where



J. T. Bregger, U.S. Soil Conservation Service

Figure 26. This is a diagram for terracing and planting an orchard on rolling topography. Points A to R were established on the steepest slopes at the minimum allowable distance between tree rows. Each point has been projected along the contour to the left and right with an engineer's level. Terrace channels will be constructed at the lines thus established and a row of trees planted on each terrace ridge. Wherever the distance between two adjacent through rows became twice the minimum interval, a *spur* row of trees was inserted as shown by the dash line.



C. L. Hamilton, U.S. Soil Conservation Service

Figure 27. A terrace channel discharging water onto a well-sodded waterway. The water spreads as it leaves the terrace channel, some of which will be absorbed in the soil; the balance will move to lower areas. It is essential that such waterways be kept well sodded.

the slope and contour is relatively uniform, it may be possible to line up the trees across the contour line to give the orchard a better appearance and perhaps better air drainage.

In the contour system of planting, the orchard roads are placed where they will be less likely to receive and carry runoff water, resulting in erosion. Such locations will include not only the natural ridges on top of the hill, but, where terracing is used, the tree row middles just below the large terraces. The tree rows should be somewhat further apart where roads are located in order to permit necessary room for orchard trucks.

Terracing. Contour planting with terraces is used in areas where the rainfall exceeds 35 inches a year and it is necessary at times to divert some of the water from the field. From the functional standpoint, the types of ter-

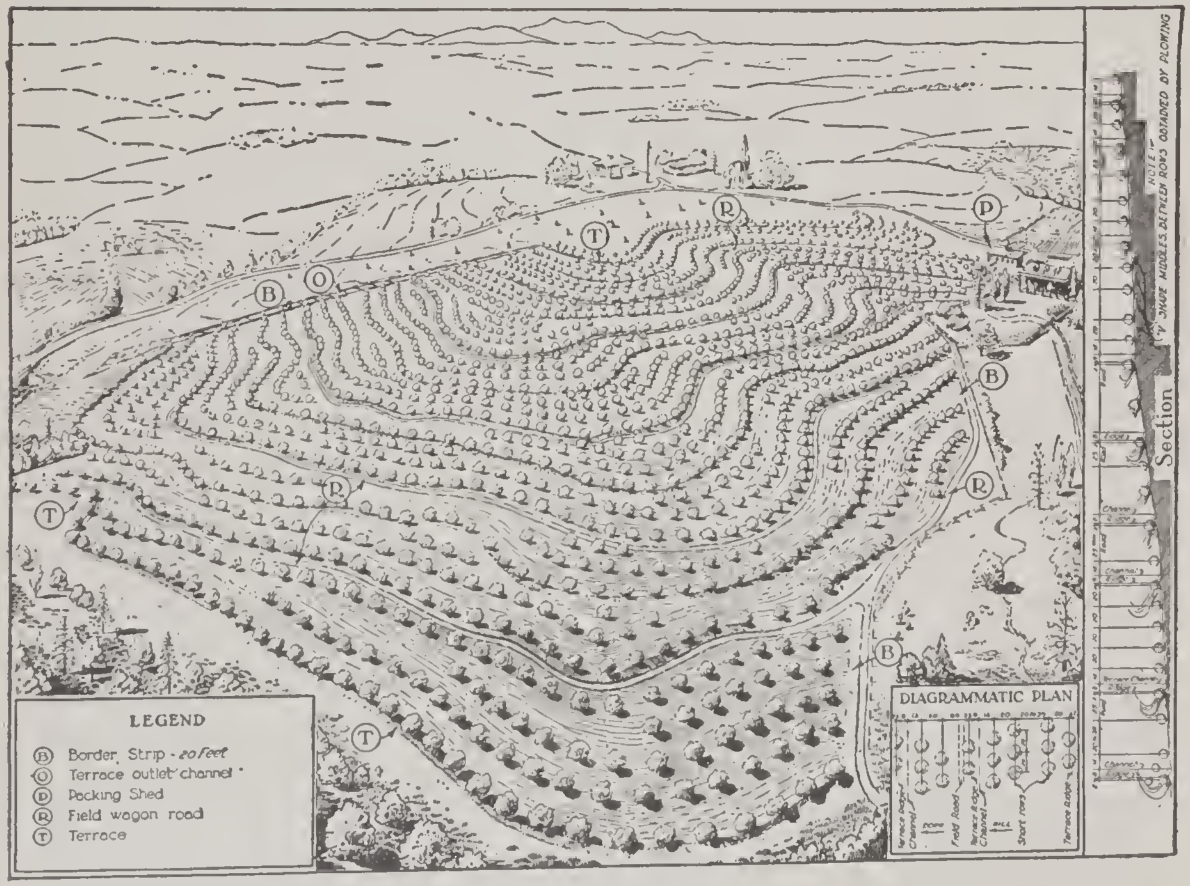


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Figure 28. Bird's-eye view of a peach orchard on sloping land showing terraces, wagon roads, placement of tree rows, terrace outlet channel, and border strips. Note the roads are located immediately below the main terraces.

races may usually be classified as of either the diversion type which has one or more outlets and discharges water, or the absorption type which is level and retains water until it is absorbed by the soil. On steep land with a slope greater than 10 per cent, bench terraces may be used, but they may be more expensive to construct. They resemble large steps up the side of the hill. On slopes greater than 10 per cent it is probably better to use permanent sod with mulch. With diversion terraces, it is necessary to have a slight downward grade in the channel floor in order that the water will run toward the terrace outlet (Figure 27). The amount of grade varies between 0.3 and about 1 per cent, depending upon the amount of slope, length of terrace, rainfall, and type of soil. From Table 3 it is possible to determine the distance between terraces based upon the land slope. If there is a water outlet at both ends of a terrace, the highest point in the channel floor usually is about midway between the ends at which point the water is directed to the left and to the right.

Before laying out the terraces or contour lines, one should go over the field carefully to determine the points of steepest slope and where the terrace outlets and drainage ways are to be located (Figure 28). Draws and swales are the natural places for discharging water from the terraces during the period of runoff and should be used wherever feasible for either a natural terrace outlet already stabilized with vegetation or as a location for a constructed waterway.

The Alabama or Nichols terrace has been used most in planting orchards in the southeastern United States. This terrace has a broad shallow channel with a moderate-sized mound on the lower side (Figure 29). The lower

TABLE 3

A Guide for Determining the Vertical and Horizontal Distance between Terraces Based on the Land Slope[1]

Slope of Land in Feet Per 100 Feet	Vertical Distance or the Drop Between Terrace Ridges	Approximate Horizontal Distance Between Terrace Ridges
1 foot	2 feet 6 inches	180 feet
2 feet	2 feet 9 inches	140 feet
3 feet	3 feet 0 inches	100 feet
4 feet	3 feet 3 inches	80 feet
5 feet	3 feet 6 inches	75 feet
6 feet	3 feet 9 inches	63 feet
7 feet	4 feet 0 inches	57 feet
8 feet	4 feet 3 inches	53 feet
9 feet	4 feet 6 inches	50 feet
10 feet	4 feet 9 inches	48 feet
12½ feet	5 feet 4 inches	43 feet
15 feet	6 feet 4 inches	40 feet

[1] From Clemson Agricultural College Extension Bulletin 97, December, 1936.

How to Use Table 3. After the slope of the hill has been determined, select from Table 3 either the vertical or horizontal distance that will apply to the slope determined. By use of the level and rod, locate the first terrace. Raise the target the amount of the vertical distance, then place the target down the hill until it is level with cross hairs in the level.

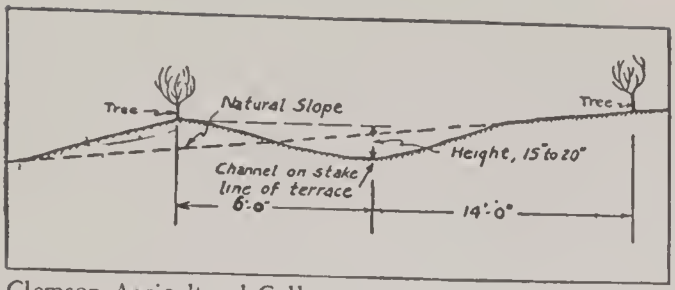

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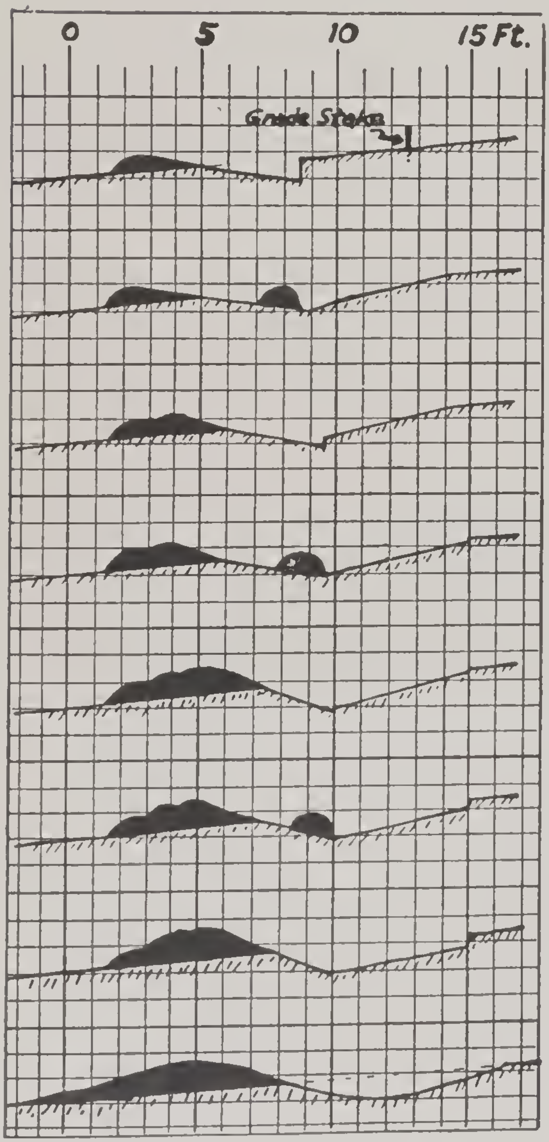
Figure 29. Cross section of a completed Alabama (Nichols) terrace after being maintained for a year or so. Recent experiments have indicated that the tree on the left should be placed at the top of the ridge. Unterraced rows, as shown by the tree on the right, should be gradually ridged by special subsequent cultivation practices.



Step 1. Cut four feet below grade stake, throwing dirt downhill.

Step 2. Cut upper side of ditch, throwing dirt into ditch.

Step 3. Clean ditch and cut additional depth.

Step 4. Cut upper side of ditch, throwing dirt into ditch.

Step 5. Clean ditch and cut additional depth.

Step 6. Slope upper side of ditch and throw dirt into ditch.

Step 7. Clean out ditch—the completed terrace.

After two years. Cross section of same terrace after two years maintenance with turn plow.

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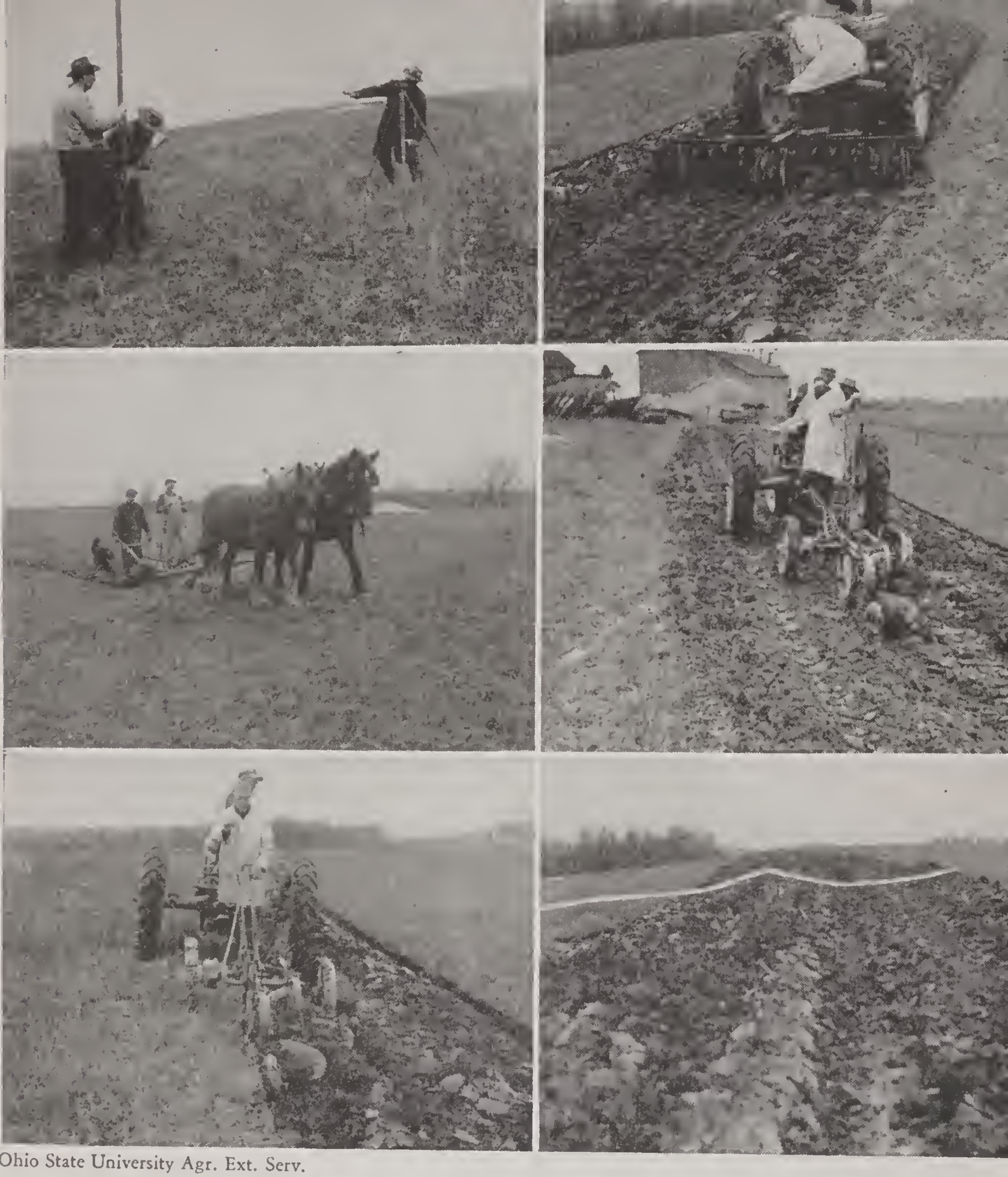
Figure 30. Seven steps in building the Alabama (Nichols) terrace with blade grader equipment shown in Figure 31.



Ohio State University Agr. Ext. Serv.

Figure 31. Steps are shown for construction of terraces with machinery and equipment found on most farms. (Top left) Advice and assistance are given by men from state agricultural extension service and an engineer from the U.S. Soil Conservation Service. Lath stakes and an engineer's target and level are used in laying out the contour lines. (Middle left) Using the lath stakes as markers, the contour lines are plowed out where terrace ridges will be located. (Bottom left) Several rounds are made with a double-bottom plow throwing dirt from either side toward the top of the ridge. (Top right) A disk is used to break up the large clods. (Middle right) One or two more rounds are made with the plow to throw the dirt further up toward the top of the ridge to build it up. (Bottom right) The completed terrace. This terrace can be further built up and maintained by proper use of a one-way disk as shown in Figure 33.

TABLE 4

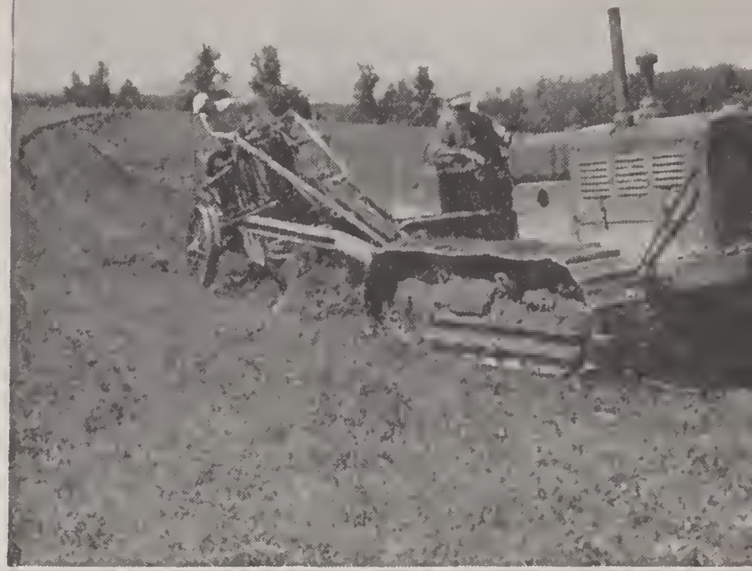
A Guide for Giving the Terrace Grade Based on the Soil Type, Slope of Land, and Length of Terrace[1]

Sandy Subsoil					Clay Subsoil				
Number 25-Foot stations (stakes)	Fall Per Station, Inches	Total Length Feet of Terrace	Max. Fall of Terrace Channel Per 100 Feet, Inches	Total Fall, Inches	Number 25-Foot Stations (Stakes)	Fall Per Station, Inches	Total Length of Terrace, Feet	Max. Fall of Terrace Channel Per 100 Feet, Inches	Total Fall, Inches
Land Slope 0–6%					Land Slope 0–6%				
16	0	400	0	0	12	⅛	300	½	1½
16	⅛	800	½	2	12	¼	600	1	4½
16	¼	1200	1	6	12	½	900	2	10½
16	⅜	1600	1½	12	12	¾	1200	3	19½
16	½	2000	2	20	12	1	1500	4	31½
					20	1¼	2000	5	56½
Land Slope 7–12%					Land Slope 7–12%				
8	0	200	0	0	12	¼	300	1	3
12	⅛	500	½	1½	12	½	600	2	9
12	¼	800	1	4½	12	¾	900	3	18
12	⅜	1100	1½	9	12	1	1200	4	30
12	½	1400	2	15	12	1¼	1500	5	45
12	⅝	1700	2½	22½	20	1½	2000	6	75
12	¾	2000	3	31½					

[1] From Clemson Agricultural College Extension Bulletin 97, December, 1936.

Note. The above table should be used as a guide and not as absolute rule, as each field may present a different problem.

slope of the mound is about four feet, the upper is six feet, the width of the channel is from 10 to 12 feet, and the depth of the channel is from 15 to 20 inches. As shown in Figure 29, it may not be necessary to have a terrace for each row of trees.

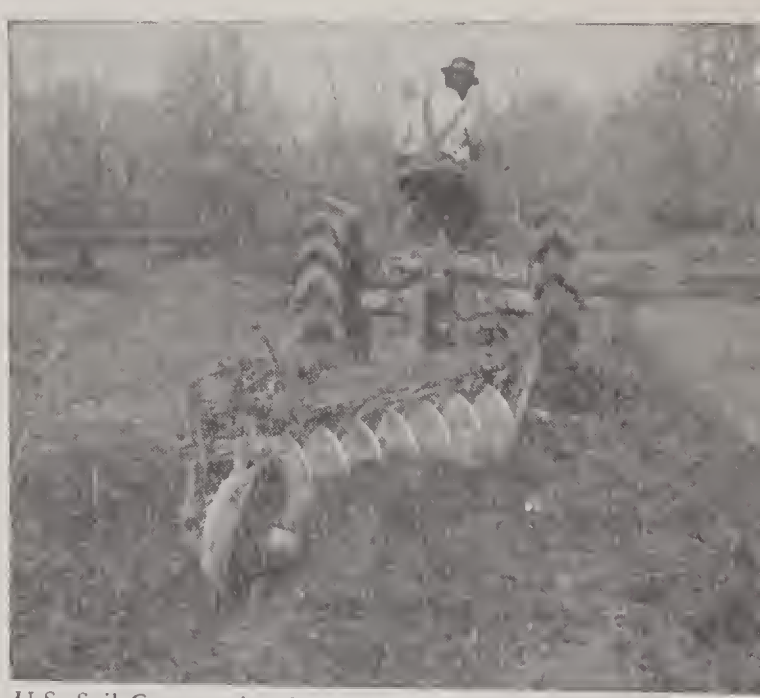


A. F. Hallowell, U.S. Soil Conservation Service

Figure 32. Building a terrace with power-blade grader equipment in New York.

Terraces can be built with larger power units similar to road grading equipment (Figures 30, 32), or they can be built with ordinary plow or disk tiller. The large power units are usually available through the Soil Conservation Service and if the grower desires to hire his terracing done, this type of equipment is satisfactory and reasonable in cost. Figure 31 shows the use of ordinary farm plow and disk equipment to build terraces. A horse-drawn drag pan or fresno is necessary terrace equipment for use in opening the outlets at the end of the terraces and also for maintenance of the terraces in filling in washed-out areas.

Special attention must be given to the maintenance of terraces in order that they continue to operate properly. Maintenance can be done with terracing implements, with terracing plows (Figure 33), or by using disk harrows set to throw the soil one way. During the process of cultivation of the trees, all terrace channels should be plowed or disked so that the soil will be thrown both ways from the bottom of the channel. *If breaks should occur in the terraces during periods of excessive rainfall, they should be built up immediately with soil 25 per cent higher than required in order to allow for settling.* Failure to maintain terraces in this manner is one of the greatest weaknesses of fruit growers using contour terracing.



U.S. Soil Conservation Service

Figure 33. A one-way disk plow which is valuable for constructing terraces, maintaining them, and for cultivating on either side of young trees.

Review Questions

1. List 5 advantages of locating the fruit enterprise in a region where fruit growing is well established near large centers of population.

2. What is the most important climatic factor to consider in selecting a region for fruit growing?
3. How do large bodies of water influence temperature conditions along the shore line?
4. What program can an orchardist follow to obtain cash income while his fruit trees are coming into bearing?
5. What are the qualifications of a good orchard site?
6. What are the characteristics of a good orchard soil?
7. In northern states, what tree fruits can be planted in spring or fall with about the same degree of success?
8. What planting systems are used for fruit trees? Which is the most common system?
9. What are the advantages of contour planting with terraces?
10. What factors govern the planting distance of fruit trees?
11. What are the advantages of buying 1-year apple and pear nursery trees as compared with older trees?
12. What is a double-worked tree? What are its advantages?
13. Define a certified tree.
14. What are the advantages of semidwarf trees grafted on vegetatively uniform rootstocks?
15. Briefly list the steps in properly planting a fruit tree.
16. Describe a Nichols terrace, giving approximate dimensions.
17. What tree fruits would you advise growing on land which is too steep for terracing and cultivation?

Suggested Collateral Readings

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CHAPTER III

Apple Regions, Production, and Varieties

The apple has been cultivated in Europe for over two thousand years. Seed and grafted trees of the better European varieties were brought to North America and planted by the earliest settlers. Seed from these trees were rapidly disseminated westward by the Indians, traders, and missionaries. In this connection, the well-known legend is often told of how Johnny Appleseed (John Chapman) assisted in the planting and spreading of apple seed among the westward moving families.

Later in 1847, it was Henderson Lewelling who took a load of nursery stock by ox team and wagon from Iowa to Oregon. Since that time, apple trees have been planted widely over the United States and Canada and commercial plantings have developed rapidly in those regions best suited for apple growing. Today, it is interesting to note that most of the deciduous fruit growing regions have been determined largely on the basis of apple growing. It is true, however, that some plants, particularly peaches, will not thrive in all apple sections due to low winter temperatures.

The relative importance of each state in apple production is shown in Figure 34. Until 1923 the state of New York led all other states in apple production, but in that year Washington assumed the lead and recently has been producing about twice as many apples as New York, the second in line. Washington's average production from 1937-46 was 27,607,000 bushels; New York, 15,059,000; and Virginia, 10,698,000. Other states ranking in order were Pennsylvania, California, Michigan, Ohio, and West Virginia.

Figure 35 shows the distribution of apple trees of all ages in the United States. This map has been divided into six regions mainly on the basis of climate and varieties grown. It is apparent that over 75 per cent of the apple crop is obtained from the Northeastern (I), Central Atlantic (II), and West Coast states (VI). The sections will be described separately in order to bring

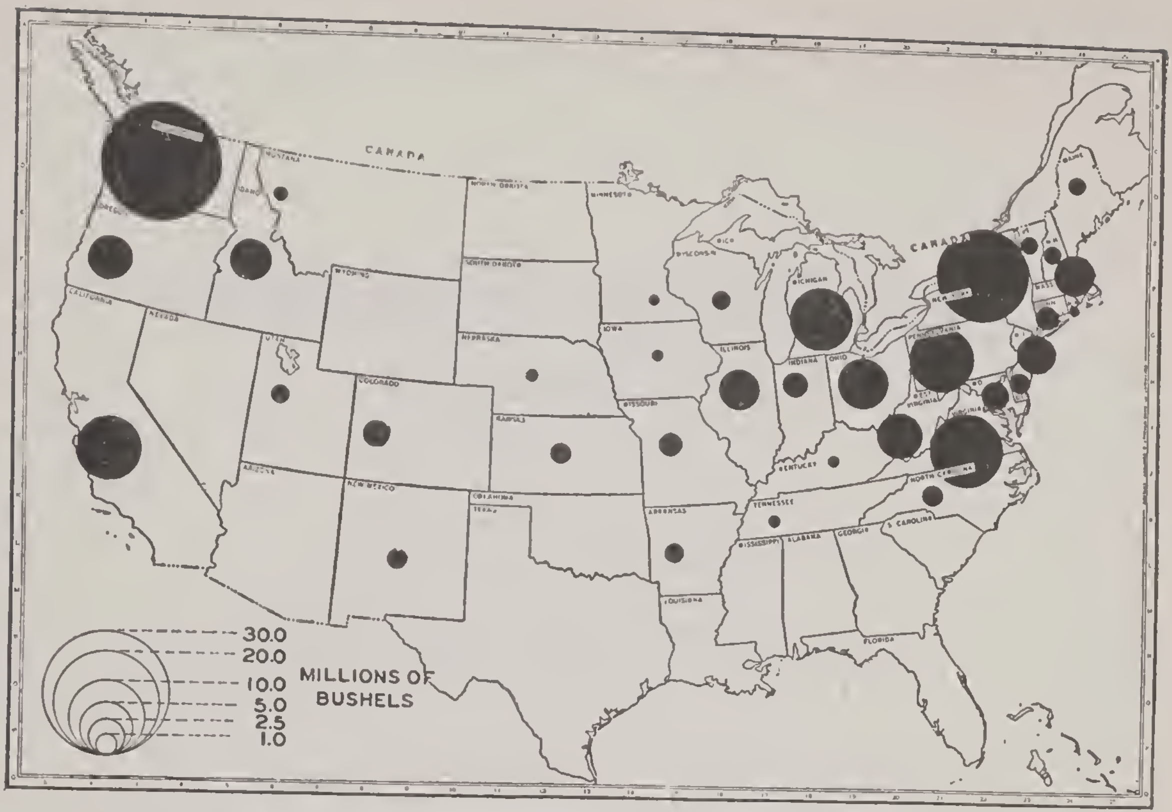
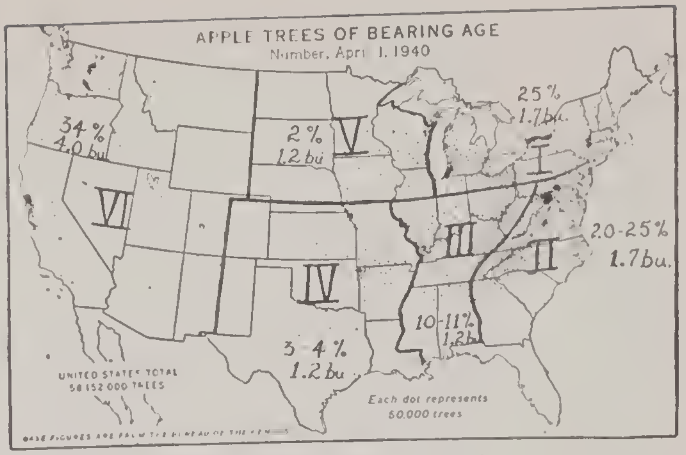


Figure 34. The average annual production of apples by state in the United States from 1938 to 1947.

out the important factors governing apple regions and some of their respective problems. It is suggested that frequent reference be made to Figure 35 in order to "picture" the areas under consideration.

Northeastern section (I). About 25 per cent of the apple crop in the United States is produced in this area. Temperatures during the growing season are moderately cool, ranging between 65 and 70° F. from June to August, inclusive. Along the southern boundry of this section, the time from apple bloom in spring to the first freeze in fall allows the use of apple varieties which will mature within from 155 to 160 days from time of bloom. In the northern regions of this section where the growing season is shorter, as well as across the border in Canada, it is necessary to select varieties maturing in 140 to 150 days. Until recently, Baldwin was the major variety but extreme temperatures in the winter of 1933–34 eliminated many trees of this variety. McIntosh has become the leading variety; Cortland also has been planted extensively. Other important varieties are Rhode Island Greening, Northern Spy, Wealthy, Delicious, Ben Davis, and Oldenburg (Duchess). Jonathan and Wagener are grown considerably in Michigan but not in other states. Stayman Winesap and Rome Beauty are popular in the southern parts of this section.

The rainfall in New England and New York averages about 45 inches. In western New York, northern Ohio, and Michigan, the average is between 30 and 35 inches annually. About half of this rainfall comes during the growing season between April to September, inclusive, and it is unusually dependable—more so than in any other major apple section in the United States. In orchards on moderately deep and well-drained soil, there is little danger of serious moisture shortage. This is due to a combination of dependable rainfall conditions and cool growing season. The Great Lakes have an important moderating effect on the temperature.



U.S.D.A. Bureau of Agricultural Economics

Figure 35. Distribution of apple trees in the United States according to the 1940 U.S. Census. The United States is divided into six regions on the basis of climate, varieties, and other factors. The percentage production of the total United States crop and the yield per tree are indicated in each region.

Central Atlantic section (II). This section produces from 20 to 25 per cent of the total apple crop. In most of the area, the average summer temperatures are about five degrees higher than in the Northeastern section, (I), ranging between 70 and 75° F. Some orchards are planted as high as 2000 feet above sea level in the Appalachian Mountains, and the temperature at this height ranges between 65 and 75° F. Relatively few apples are grown in North and South Carolina and southward due to warmer temperatures, averaging above 75° F. Most of the apples grown in the southern parts of this section are necessarily located at higher altitudes in the Appalachian Mountains. Winter freezing of trees is hardly a factor in this region due to the fact that minimum temperatures rarely go below —10 to —15°. In the mountainous areas, there are many orchard sites which permit good air drainage where there is less possibility of spring frosts.

Rainfall ranges between 40 and 45 inches for most of the section with the exception of the Potomac Valley where it is somewhat lower. From April to September, inclusive, about 22 inches of rain falls, but long periods of drought seem to occur more frequently than in the Northeastern section (I). Soils which permit deep rooting and cultural methods for conservation of moisture are necessary.

Varieties should be selected for the northern part of this section which require 160 to 165 days for maturity. Varieties requiring longer periods of development can be grown in the southern section. In the northern areas, Stayman Winesap is the leading variety. York Imperial is the leading variety in West Virginia and northern Virginia with Winesap taking the limelight further south. Delicious has been widely planted in recent years. Approximate rank of the varieties throughout the region is: Stayman Winesap, York Imperial, Winesap, Delicious, Rome Beauty, Ben Davis, Grimes Golden, Jonathan, and Yellow Transparent.

The Ohio Basin section (III). About 10 to 11 per cent of the apple crop in the United States is produced in this region. The June to August temperature averages about 75° F. The length of the growing season is approximately the same as that in the Central Atlantic section (II) for the northern and southern areas. Along the Ohio River where apple orchards are most concentrated, the annual precipitation is around 40 inches with about 20 inches occurring during the growing season. In the southern section, rainfall may reach 50 inches. However, due to the fact that temperatures are higher during the growing season, there is greater need for water than in northern sections of the United States. The drought periods under these conditions tend to be more injurious to the trees. If the orchards are in soils of good water-holding capacity to a depth of three to four feet, serious damage to the trees in prolonged drought is not likely to occur.

Several varieties are popular throughout the region; namely, Rome Beauty, Grimes Golden, Jonathan, Stayman Winesap, Delicious, Winesap, Ben Davis, and Yellow Transparent. In Tennessee, early summer varieties, Yellow Transparent and Early Harvest, are widely planted in commercial orchards. In Illinois, Jonathan is the most important with Yellow Transparent second. Delicious and Golden Delicious are becoming more important. In western Illinois, it is interesting to note that Willow Twig has gained prominence.

Southwestern section (IV). Only 3 to 4 per cent of the apple crop is produced in this section. The temperatures between June and August are high, averaging between 75 and 80° F. The growing season is relatively long. Most of the rainfall occurs in Arkansas, with an annual precipitation of 45 to 50 inches; in southern Missouri, 40 to 45 inches; in northern Missouri and eastern Kansas, 35 to 40 inches; and in Nebraska, western Kansas, and western Oklahoma, below 35 inches. In regions where precipitation is under 30 inches per year, relatively few apples have been planted.

Jonathan is the leading variety in most of this section. Other important varieties are Delicious, Winesap, Grimes Golden, and Stayman Winesap. Ben Davis was the leading variety, but it has declined rapidly as a result of blister canker disease and a succession of dry summers from 1930–36.

Northcentral section (V). This is not an important apple raising section. Only about 2 per cent of the total apple crop is produced here. Through most of the section, summer temperatures range from 65 to 70° F. In the southern section, however, the range is between 70 and 75°, whereas in northern Wisconsin, it is relatively cool, or under 65°. Varieties with moderately long growing seasons can be grown in the southern section, whereas in the northern areas, it is necessary to plant varieties which are outstandingly resistant to low winter temperatures. Rainfall in the apple sections is relatively low, ranging from 25 to 35 inches. In the western part of this section, rainfall is less, and apples are grown primarily in home plantings. In general, less water is needed, however, due to the lower mean temperatures. Extreme winter cold is the main hazard. Most states in this region are carrying on an extensive breeding program for winter resistant varieties.

In southern Iowa and along Lake Michigan in Wisconsin, varieties commonly grown are Jonathan, Grimes Golden, Delicious, and to some extent Stayman Winesap and Winesap. In the northern section, such hardy varieties as Wealthy, McIntosh, Oldenburg, and Yellow Transparent are grown.

Special cold resistant varieties have been developed; namely, the Harlson in Minnesota, the Joan and Secor in Iowa, and the Anoka in South Dakota. These varieties are considered promising in the respective states.

Western section (VI). This section is responsible for about 34 per cent of the entire apple crop of the United States. As shown in Figure 35, the apple regions are concentrated in scattered areas which usually occur in valleys surrounded by mountains. Commercial apple production for the region as a whole has increased rapidly during the past 35 years; it is characterized by a relatively high production per tree and per acre. The production from one year to the next has been remarkably uniform due, primarily, to the clear almost cloudless days throughout the summer, regular water supply from irrigation, and relative freedom from spring frosts and freezes. The production for this area of four bushels per tree is two and three times higher than for other apple sections in the United States, as shown in Figure 35. In Washington State, alone, the average yield is almost seven bushels per tree. Size and color of the apples, also, are generally better as compared with eastern apples.

The higher acre yield of better-quality fruit in the Western section tends to overcome the relatively higher cost of production which is due, essentially, to the necessity for irrigating, better packaging, higher labor costs and tax rates, more intensive production practices in pruning, fruit thinning, spraying, and long transportation distances. Only 9.7 per cent of the total population of the United States existed in the Western section in 1935. Hence, the important consuming centers for western fruit are from 2000 to 3000 miles across the United States to the eastern coast. The cost of cross-country transportation in refrigerated cars is between 75 cents and $1.00 per box.

It is true that western fruit usually sells for better prices than the eastern fruit, but the returns to the western grower on a bushel basis have been generally less than that obtained by the eastern growers, especially when apple prices are low. However, with high apple prices, such as occurred during and after World War II, the greater productiveness of the western orchards resulted in good returns.

The commercial districts of this Western region (VI) will be discussed separately due to their extent and commercial importance.

Wenatchee district. This district lies in northcentral Washington in the valley of the Columbia River and along its tributaries. Most of the orchards are located along the rivers on more or less bench land with sufficient elevation for good air drainage. Spring frosts are rarely a factor. The summer day temperatures are relatively high and the nights are cool with an average June to August temperature of 65 to 70° F. Rainfall is very low, amounting to from seven to ten inches per year, and most of this falls in the winter months. The soils are deep, however, and irrigation is extensively practiced, applying 30 to 35 inches of irrigation water in addition to the rainfall.

Yakima Valley district. In Washington, the Yakima Valley ranks second to the Wenatchee district in apple production. It lies about 100 miles south

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of the Wenatchee district in the valley of the Yakima River. Conditions are similar to the Wenatchee district except that the frost hazard is somewhat higher due to the broad and more or less level valleys. There are some areas, however, which have excellent air drainage. Special precaution in irrigation is necessary due to the fact that some of the orchards are on light and rather shallow soils.

Other Washington districts. Apple trees are extensively planted in eastern Washington along the valley of the Spokane River. Winter freezing injury has been a factor in this region at times. In the Walla Walla district in southeastern Washington State, the apple industry has receded somewhat due to high summer temperatures and a high frost hazard. There is another region, small but intensively planted, known as the White Salmon district located in southern Washington opposite the Hood River Valley in Oregon.

The Delicious variety leads for the state as a whole, accounting for 35 per cent of the total. Winesap is second with 33 per cent followed by Jonathan, 11 per cent; Rome Beauty, 8 per cent; and Yellow Newtown, 3 per cent. These five varieties comprise 90 per cent of the plantings.

Oregon district. The largest apple district in Oregon is located in the valley of the Hood River in the northcentral part of the state. Production in this area has decreased in the past 20 years due to a canker disease and winter injury. At one time, the Hood River Valley was one of the most famous of the Western apple districts. Production is still good but not comparable to that in Washington State. Summer temperatures are cool, ranging around 65° F. The leading varieties are Yellow Newtown, which is far ahead of Delicious, Esopus Spitzenberg, Rome Beauty, and Ortley.

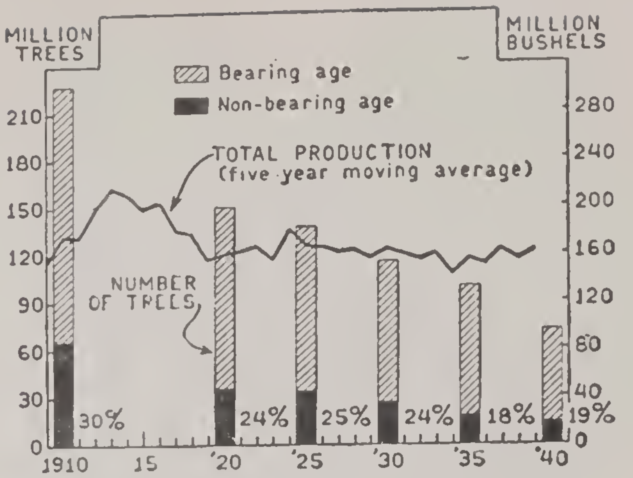
Apple trees at one time were planted in rather large numbers in the Rogue River Valley in southern Oregon and the nonirrigated Willamette Valley in western Oregon. However, the apple trees have been largely replaced by pear trees, the climate for which seems to be more favorable.

California districts. There are three main apple regions in California. One lies north of San Francisco where it is cool, rainfall is about 40 inches, and irrigation is rarely needed. The main variety is Gravenstein, which is harvested in July and distributed widely throughout the United States as an early summer apple. Other varieties include Rome Beauty, Jonathan, and Yellow Newtown.

The second region lies south of San Francisco where it is also cool, but rainfall is only 25 to 30 inches, and some irrigation is practiced. Leading varieties are Yellow Newtown and Yellow Bellflower. Foggy weather is frequent in this area and as a result, yellow varieties are used because red apples do not color well from lack of sufficient sun.

The third and most important apple district is located in southern California 100 miles east of Los Angeles, necessarily at an altitude of about 2500 to 3500 feet to obtain sufficient cold for breaking the winter rest period of the trees. Precipitation is about 20 inches and irrigation is practiced from wells. Rome Beauty, Winesap, and Delicious are the chief varieties.

Idaho districts. The main district in Idaho is located in the southwestern part of the state along the tributaries of the Snake River near the Oregon line. The orchards are located at an altitude of 2000 to 3000 feet where the summer temperatures average about 70° F. Frost damage is a factor in the broad valley floors where air drainage is poor. High water table also has been a detrimental factor in some of the irrigated orchards. Leading varieties are Rome Beauty, Jonathan, Delicious, and Winesap.



T. A. LaMont and Edwin Smith, Cornell University

Figure 36. Graph shows trend in apple production and number of bearing and nonbearing trees in the United States from 1909 to 1940. The decline in number of trees has been more pronounced than the decline in production. Better sites and cultural practices in recent years account for the higher production per tree.

Utah districts. Most of the Utah orchards are located adjacent to the Great Salt Lake on the south and southeast shores. Production has never assumed large proportions in this district which lies at an altitude of about 4000 feet where the average summer temperature is 70° F. Winter injury has been a limiting factor, as well as insect control. Jonathan is the leading variety with Rome Beauty and Delicious following in order.

Western Colorado districts. Apple regions are located in the westcentral part of the state in the valley of the Grand River and its tributaries. Recently, most of the orchards have been planted at higher elevations to overcome the difficult codling moth problem and poorly drained soils in the valleys. Jonathan, Rome Beauty, and Delicious are popular.

Other western districts. Apples in Montana are planted along the Bitterroot River where winter injury is a factor and cold-hardy varieties such as McIntosh are used. In New Mexico, apples are located largely along the San Juan River where Delicious, Rome Beauty, Jonathan, and Winesap are the leading varieties.

Trend in apple trees and production. Since 1910, there has been a decrease in total number of apple trees and apple production in the United States, as shown in Figure 36. It will be noted that the decline in apple production, however, has been less than the decline in number of trees. For example, almost as many apples were produced in 1935 as in 1910 with about half the number of trees. This is due, no doubt, to the better selection of sites and soils in recent years and to the use of better cultural practices. The general decrease in number of apple trees and production in recent years can be accounted for by a decrease in demand for apples as a result of a somewhat greater consumption of other fruits, such as citrus. The per capita consumption of apples in recent years has been between 25 and 30 pounds and for citrus, between 50 and 60 pounds, or about twice as much.

TABLE 5

Apple Trees of Leading Varieties in Commercial Orchards in the United States in 1928, Notes as to Trends Since That Time, and Production During 1942–45, Inclusive[1]

Variety	Apple Trees in 1928		Trend Since 1928[2]	Production in 1000's of Bu. 1942–45, Inc.[3]
	Estimated Number	Per cent of Total		
1. *Delicious*	6,826,000	8.4	*Moderate increase*	18,731 (1)
2. Winesap	6,617,000	8.2	Steady	12,069 (2)
3. Jonathan	6,334,000	7.8	Slight decrease	7,597 (4)
4. Baldwin	5,519,000	6.8	Marked decrease	3,893 (9)
5. Stayman Winesap	5,076,000	6.3	Steady	5,712 (6)
6. Ben Davis	4,529,000	5.6	Marked decrease	2,661 (+Gano) (10)
7. Rome Beauty	4,180,000	5.2	Steady to slight increase	5,791 (5)
8. York Imperial	3,604,000	4.5	Steady to slight decrease	5,701 (7)
9. *McIntosh*	3,340,000	4.1	*Marked increase*	9,279 (3)
10. Grimes Golden	2,465,000	3.0	Moderate decrease	2,071 (13)
11. Yellow Newtown	2,326,000	2.9	do.[4]	4,430 (8)
12. Wealthy	2,073,000	2.6	do.	1,953 (15)
13. Yellow Transparent	1,863,000	2.3	do.	....
14. Gano and Black Ben	1,769,000	2.2	do.	See Ben Davis
15. Rhode Island Greening	1,451,000	1.8	do.	1,964 (14)
16. Northern Spy	1,395,000	1.7	do.	1,706 (16)
17. Gravenstein	1,285,000	1.6	Steady to slight decrease	2,154 (11)
18. Oldenburg (Duchess)	1,197,000	1.5	Marked decrease	....
19. Arkansas (Black Twig)	970,000	1.2	do.	836 (18)
20. *Golden Delicious*	941,000	1.2	*Marked increase*	2,104 (12)
21. Esopus Spitzenburg	592,000	.7	Marked decrease	....
22. Wagener	583,000	.7	Moderate decrease	....
23. Stark	524,000	.6	do.	....
24. Winter Banana	439,000	.5	Marked decrease	....
25. King David	416,000	.5	do.	....
26. Limbertwig	338,000	.4	Moderate decrease	....
27. Tompkins King	324,000	.4	Marked decrease	....
28. *Cortland*	303,000	.4	*Marked increase*	1,217 (17)
29. Yellow Bellflower	296,000	.4	Moderate decrease	....
30. Miscellaneous	13,288,000	16.5		12,693

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[1] Data on tree numbers from the mimeographed report, Estimated Numbers of Apple Trees by Important Varieties and Ages in Commercial Orchards in 41 States. U. S. Dept. Agr. Bur. Agr. Econ., in co-operation with state colleges and state departments of agriculture, 1946.

[2] Personal opinion from observation by Dr. J. R. Magness, U. S. Dept. Agr., 1941 (See reference).

[3] Average for 35 states; 1945 was preliminary; the average total for all varieties during the 4 years was 102,739,000 bu.; figures in parenthesis indicate present rank of variety.

[4] In this and following Tables *do* means ditto.

Trend in varieties. In the past 25 years, there has been a definite trend toward the selection of apple varieties having high dessert quality. Table 5 gives the leading varieties of apple trees in commercial orchards in 1928 and production trends since that time. It will be noted that of 24 leading varieties, only Delicious, McIntosh, Golden Delicious, and Cortland are judged to have increased in tree numbers since 1928. The apple production data by varieties from 1942–45, shown in the right-hand column, more or less confirm this increase of popularity of these varieties. McIntosh has unquestionably shown the greatest increase in popularity. Winesap, Stayman Winesap, and Rome Beauty plantings and tree removals have been about the same; all other varieties show a decrease as the tree removals exceeded tree plantings. It will be noted that such former leading varieties as Baldwin, Ben Davis, Gano, Northern Spy, Rhode Island Greening, Early Harvest and Wealthy are definitely dropping out of the leadership.

C. E. Chase, Washington State Apple Adv. Commission

Figure 37. Delicious is the most widely planted apple variety in the United States. This is because it has a good combination of tree characters and popular high-quality fruit.

Although Delicious is widely planted and the leading variety, there is some reason to believe that it may not be as profitable as it should be over a period of years, particularly in the Northeast. This is mainly due to frequent light sets and yields.

Desired characteristics. On the basis of experience during the past two or three decades, it would appear that the most important characteristics of an apple variety to consider when making a selection are these: it must be good to very good in dessert quality, very attractive in appearance, pest-resistant, productive, and hardy. In addition, if the fruit is of good storage and good handling quality, the value of the variety is greatly increased. Some of the important characteristics which should be considered in the selection of a variety are given in Tables 6 and 7. It is not important that the student attempt to memorize all these characteristics for each variety because such a knowledge can come only with several years of experience in working in the orchard with the varieties. However, he should take note of the important characteristics, and if he should have occasion to select varieties for an orchard, these tables will be valuable for reference.

It might be of interest to compare two present day apple varieties and study why one is increasing and the other decreasing in popularity. McIntosh is rapidly increasing in popularity, Ben Davis is decreasing. McIntosh is a spreading, vigorous, large tree which bears annual crops and starts bearing early in life. Ben Davis is more or less similar in these tree characteristics. The largest difference is in the fruit. McIntosh fruit is of medium size, attractive red color, tender and juicy, medium acid, of very good dessert and good cooking quality. The fruit of Ben Davis agrees in these characteristics except that the texture of its flesh is hard, dry and tough, and the dessert quality is poor with the cooking quality only fair. It is apparent from this example that *quality* of the fruit has been almost entirely responsible for rise

TABLE 6

IMPORTANT CHARACTERISTICS OF LEADING APPLE VARIETIES[1]

VARIETY	APPROXIMATE DAYS AFTER FULL BLOOM TO PICKING MATURITY	SHAPE OF TREE	VIGOR OF TREE	ULTIMATE SIZE OF TREE	AGE TO FIRST BEARING	TENDENCY TO ANNUAL OR BIENNIAL PRODUCTION
Yellow Transparent	70 to 75	Upright	Medium	Med. to small	Early (4 to 6 years)	Biennial
Oldenburg (Duchess)	90 to 95	Spreading	do	Medium	do	Intermediate
Gravenstein	110 to 115	Upright spreading	Vigorous	Med. to large	Medium (6 to 8 years)	Annual
Winter Banana	120 to 125	Spreading	Medium	Medium	Early (4 to 6 years)	Intermediate
Wealthy	120 to 125	Upright spreading	do	Med. to small	do	Biennial
Cortland	125 to 130	Spreading	do	Medium	do	Annual
McIntosh	125 to 130	do	Vigorous	Large	do	do
Rhode Island Greening	135 to 145	do	do	Med. to large	Medium (6 to 8 years)	Intermediate
Wagener	135 to 145	Very upright	Medium	Medium	Early (4 to 6 years)	do
Stark	140 to 150	Upright spreading	Vigorous	Large	Medium (6 to 8 years)	do
Golden Delicious	140 to 145	Spreading	Medium	Medium	Early (4 to 6 years)	do
Grimes Golden	140 to 145	do	do	Med. to large	Medium (6 to 8 years)	do
Baldwin	140 to 150	Upright spreading	Very vig.	Large	Med. to rather late (8 to 10 years)	Biennial
Jonathan	140 to 145	do	Vigorous	do	Early (4 to 6 years)	Annual
Delicious	140 to 150	do	do	do	Medium (5 to 8 years)	Intermediate
Esopus Spitzenburg	145 to 150	Upright	do	do	Medium (6 to 8 years)	do
Northern Spy	145 to 155	do	Medium	Med. to large	Very late (10 to 14 years)	do
Ben Davis	150 to 155	Upright spreading	do	Medium	Early (4 to 6 years)	Annual
York Imperial	155 to 165	do	Vigorous	Large	Medium (6 to 8 years)	Biennial
Rome Beauty	160 to 165	Spreading	Medium	Med. to small	Early (4 to 6 years)	Annual
Yellow Newtown	160 to 165	Upright spreading	do	Medium	Medium to late (8 to 10 years)	Biennial
Stayman Winesap	160 to 165	Spreading	Vigorous	Large	Early (4 to 6 years)	Annual
Winesap	160 to 170	do	Medium	Medium	Medium (6 to 8 years)	Intermediate
Arkansas (Black Twig)	165 to 170	Upright spreading	Vigorous	Large	Medium to late (8 to 10 years)	Biennial

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[1] Adapted from: Magness, J. R., Apple varieties and important producing sections in the United States. U. S. Dept. Agr. Farmers' Bull. 1883, 1941.

or fall in popularity of these two varieties. The same reason accounts for the fact that Baldwin, Wealthy, Rhode Island Greening, Tompkins King, and others are decreasing in popularity.

Color strains. There are a number of bud sports of popular varieties on the market which are supposedly the same as the parent except that they have more red color. However, a considerable degree of caution should be taken in the use of any or all color strains. There are some cases where they have been propagated with relatively little preliminary trial. Although the best color strains of the red apple varieties appear to have considerable merit, there is no assurance that these strains are identical in every respect except color to the parent variety. The size, storage quality of the fruit, and other factors may also be different. In some cases, the shade of color in the strain appears to be deeper than the parent, and, in fact, so deep that the color is dull and unattractive. Thus, it is important that the prospective grower of such color strains make every effort to see bearing trees of the strain and make his own decision if it is better than the parent. Perhaps the best approach is to plant a tree or two of the strain to obtain first-hand information regarding its adaptation and value for his particular conditions.

There are a few of the red strains which have been grown rather extensively under commercial conditions and can be briefly evaluated as follows:

Delicious strains. Starking and Richared are the most popular. Starking reddens about two weeks ahead of the standard Delicious, but the date of maturity of the fruit is the same; hence, one must be careful not to pick the variety too soon, which has been a problem with some growers. At picking time, the Starking develops a dark maroon red when it is fully mature.

Richared does not color as early as Starking and at picking time, it is more completely colored than the standard variety. The Richared apples, in general, are as well colored as the best colored apples of the standard variety.

The Shotwell Delicious is more recent and has not been propagated so widely. So far, it appears to be a good bright color when mature.

Rome Beauty strains. Gallia Beauty is a seedling, apparently, and Cox Red Rome is of but sport origin. Both strains have a bright attractive red color more uniform than the standard Rome Beauty. The fruits are smaller, earlier maturing, and possibly not quite so good in storage quality as the standard Rome Beauty, although more experimental data are needed to verify this. The Black Rome was originated and propagated to some extent in the Pacific Northwest. It appears to be considerably darker than the standard Rome Beauty.

Stayman Winesap strains. Stamared and Blaxstayman are the most popular. Blaxstayman at maturity is darker than the parent and sometimes bears a dull shade of red. Color of the Stamared is apparently similar to that of Stayman Winesap except it averages somewhat more color at maturity. Both strains are similar to the parent from the standpoint of cracking of the fruit which is the greatest weakness of this variety.

Jonathan strains. Jonared and Blackjon are the common strains. Jonared

TABLE 7

FRUIT CHARACTERISTICS OF LEADING APPLE VARIETIES[1]

VARIETY	SIZE OF FRUIT	COLOR OF FRUIT	SHAPE OF FRUIT
Delicious	Medium to large	Medium red (blush to 100 per cent)	Oblong conic
Winesap	Medium to below medium	Dark uniform red	Conical
Jonathan	do	Uniform bright red	Round to round conic
Baldwin	Medium to large	Medium red (blush to 100 per cent).	do
Stayman Winesap	do	do	Roundish conic
Ben Davis	do	Striped medium red	Round conic to oblong conic
Rome Beauty	Large	Medium red (blush)	Round to oblate
York Imperial	Medium to large	Light red (blush to 100 per cent)	Oblate, oblique
McIntosh	Medium	Medium red (blush to 100 per cent)	Roundish oblate
Grimes Golden	Medium to below medium	Yellow	Roundish oblong
Yellow Newtown	Medium	do	Roundish oblate, sometimes oblique
Wealthy	do	Medium red (blush to 100 per cent)	Roundish oblate
Yellow Transparent	Small to medium	Yellow	Conic
Rhode Island Greening	Medium to large	Green yellow	Roundish oblate
Northern Spy	Large	Bright striped red	Roundish conical
Gravenstein	Medium	Striped bright red (blush to 100 per cent)	Oblate, angular
Oldenburg (*Duchess*)	do	Striped medium red (blush to 100 per cent)	Roundish oblate
Arkansas (*Black Twig*)	Medium to large	Medium dull red (blush to 75 per cent)	do
Golden Delicious	do	Yellow	Conic
Esopus Spitzenburg	do	Uniform bright red	Oblong conic
Wagener	Medium	Bright red (blush)	Oblate, irregular
Stark	Medium to above medium	Medium to dull striped red	Roundish conic
Winter Banana	Medium to large	Yellow, red blush	do
Cortland	Medium to above medium	Medium red	Oblate

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[1] Adapted from: Magness, J. R., Apple varieties and important producing sections of the United States. U. S. Dept. of Agr. Farmers' Bull. No. 1883. 1941.

TABLE 7—Continued

FRUIT CHARACTERISTICS OF LEADING APPLE VARIETIES—Continued

TEXTURE OF FLESH	DEGREE OF ACIDITY	DESSERT QUALITY	COOKING QUALITY	COLD-STORAGE SEASON		TENDENCY TO STORAGE SCALD
				Normal days[2] (number)	Maximum days[3] (number)	
Crisp, juicy, mealy when overripe	Low	Very good	Poor	90 to 120	180	Slight
Hard, crisp, juicy	Medium	Good	Good	150 to 210	240	Medium
Tender, crisp, juicy	Medium to high	Very good	do	60 to 90	120	Slight[4]
Hard, crisp, juicy	Medium	Fair to good	do	120 to 150	180 to 200	Medium to severe
Firm, crisp, juicy	do	Very good	Very good	120 to 150	150 to 180	Severe
Hard, dry, tough	do	Poor	Fair	120 to 150	240	Medium
Firm, crisp to mealy when overripe	Medium to below medium	Fair	Good	120 to 150	180 to 210	do
Hard, crisp	Medium	do	do	120 to 150	150 to 180	Severe
Tender, juicy	do	Very good	do	60 to 90	120 to 150	Slight[4]
Medium tender, crisp, juicy	do	Good to very good	do	60 to 90	120	Severe
Hard, crisp, juicy	Medium to above medium	Very good	do	150 to 180	240	Slight
Tender, crisp, juicy	Medium to high	Good	do	0 to 30	90	do
Medium tender, juicy	Very high	Poor	do	0	90	None
Firm, fine grained, juicy	Medium to high	Good	Very good	90 to 120	180	Severe
Firm, fine grained, tender, juicy	Medium	Very good	do	120 to 150	180	Slight
Firm, crisp, juicy	Medium to high	Good	do	0 to 30	90	do
Firm, juicy, rather coarse	High	Poor	Good	0 to 30	90	do
Hard, crisp, coarse, juicy	Medium	Fair to good	do	120 to 150	180	Severe
Firm, crisp, tender	do	Very good	do	90 to 120	150	Slight
do	Medium to high	do	Very good	90 to 120	180	do
Firm, crisp, juicy	Medium	Good	Good	90 to 120	120 to 150	Severe
Firm, crisp, coarse	do	Fair to good	do	120 to 150	180	Slight
Firm, tender, rather coarse	Medium to low	do	Fair	90 to 120	150	do
Tender, moderately juicy	Medium	Good to very good	Good	90 to 120	150	Medium

[2] Represents the time that most of the fruit may be safely held.

[3] Represents the maximum period for safe holding of fruit picked, handled, and stored under the best conditions.

[4] Susceptible to soft scald.

appears to have a somewhat brighter color, the Blackjon being blacker than the parent. Jonared carries considerably more color than the parent variety.

Other varietal strains. There are red color strains of other red apple varieties, such as York Imperial, Baldwin, Northern Spy, McIntosh, Esopus Spitzenberg, Gravenstein, and Oldenberg. Sufficient information, however, is not available for discussion. It would be well for the grower to see these varieties and judge for himself.

The original and earlier trees of the McIntosh variety apparently were of a good solid red type of color. However, in recent years there have been mutations to a striped type which is not very attractive. It would be well to avoid the striped strain.

Review Questions

1. List 5 leading states in apple production; what is the approximate total apple production of the United States?
2. What important factors govern the selection of varieties in Minnesota as compared with the selection for Virginia?
3. How do you account for the fact that apple production in the Wenatchee district of Washington is 2 and 3 times higher per tree and per acre than in the eastern districts; why is production more or less regular from year to year in Washington State as compared with heavy and light crop years in the eastern states?
4. What is the general trend of apple trees and apple production since 1910; how do you account for this?
5. What are the 3 leading apple varieties in the United States?
6. What apple varieties are showing increase in popularity; how do you account for this?
7. What are the general recommendations regarding the planting of color strains of standard varieties?

Suggested Collateral Readings

Anonymous. Monthly crop report for fruits. Crop Reporting Board, U. S. Dept. of Agr. Bur. of Agr. Econ. Washington, D. C.

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LaMont, T. E. and H. F. DeGraff. Making fruit farms pay. Cornell Agr. Ext. Bull. 554. January, 1943.

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CHAPTER IV

Pruning Apple Trees

It is necessary to train the young apple tree to a desirable pattern, so that the side branches will develop into strong limbs capable of bearing heavy crops of fruit without breakage. A tree which has been trained when young so that the side limbs are evenly spaced up and down and around the tree will be much easier to spray, thin, and harvest when the tree is mature. Young trees should be pruned as lightly as possible so they will grow rapidly and come into bearing earlier. As the trees reach peak bearing, the amount of pruning is gradually increased, as required, in order to remove old or undesirable wood and to maintain the tree in moderately vigorous condition for regular and efficient production of high quality fruit. With mature trees, it is important to keep the tops low and the sides within bounds in order to facilitate management. The kind and amount of pruning to be done on a tree will depend upon (1) the age, (2) existing framework, (3) condition of bark and wood, (4) growth characteristics, and (5) the fruiting habits of the variety.

Season for pruning. The majority of the pruning should be done during the dormant season (no leaves) for the following reasons: (1) The branches can be easily seen at that time; (2) Other orchard operations are less pressing; (3) There is less danger of pulling the bark away from around pruning wounds; (4) Experimental evidence has shown that dormant-season pruning has less dwarfing effect on trees than summer pruning; and (5) Pruning goes well with cool weather because the job requires much exercise in climbing.

The best time to start the pruning will depend upon the size of the job and amount of labor available. It is more hazardous to prune in November and December than later in the dormant season, because evidence has shown that extremely cold temperatures following the pruning operation are likely to result in serious freezing injury to the trees. It is better, if the situation will permit, to wait until late February when there is less danger of extremely cold temperatures. The mature apple trees should be pruned first and the young trees last, because the latter are more succulent and somewhat more subject to freezing injury. Actually, pruning wounds heal best if the cuts are made at about the time when active growth begins in the spring, but the job could be done this late only when there are a limited number of trees. Generally, it is better to play safe and start early so that the job is completed and the brush removed before spraying starts. Pruning can be performed through the blossoming period but this should be done only in an emergency.

It is sometimes advisable with young apple trees to perform a small amount of summer training, making only a few cuts to assist the tree in assuming a better shape and to prevent it from making unnecessary growth in undesired places. During periods of severe labor shortage, a certain amount of pruning can be done at apple thinning time in July by using hand shears and removing with small cuts the excessive twig growths along with the apples. At this season, the nonfruiting and weak wood can be easily spotted and removed. In early summer, some growers make a regular practice of "mopping-off" the succulent water sprouts which arise on the trunks and main limbs of mature trees. This can be done by hand, using leather gloves. Such water sprouts are essentially nonproductive wood which utilize water and nutrients needed by other branches, and also attract aphids. If the sprouts are left over winter, they contain many eggs and are, therefore, a source of aphid injury to the fruit and leaves early the next spring.

Pruning equipment. The skill with which an operator uses pruning tools is probably more important than the tools he uses. However, the fact cannot be overlooked that good tools in first-class condition and which can be nimbly handled will offer the workmen every possible advantage in doing a rapid and high-quality job with less effort. For young trees, hand shears and a "half-moon" saw are usually sufficient (Figure 38). For older trees, hand shears, long-handled pruners or "loppers," and a saw are recommended. For saving time and labor, compressed-air or pneumatic pruners with portable scaffold are increasing in popularity with the larger growers.[1]

In no case should a saw with teeth on both edges be used in orchard pruning because they are bound to cause considerable bark injury, especially in narrow crotches. It pays to buy good-quality pruning tools which will remain sharp for relatively long periods of time. The tools should be strong but as light as possible. Some lopping shears have the disadvantage of carrying too much iron which tires the pruner and reduces his daily accomplishments. Boots with rubber soles and heels, or rubber overshoes, should be worn to prevent scarring the crotches and limbs while climbing.

Making the cut. It is important to use sharp tools at all times, in order that cuts will be clean and smooth. Ragged cuts heal slowly and often poorly.

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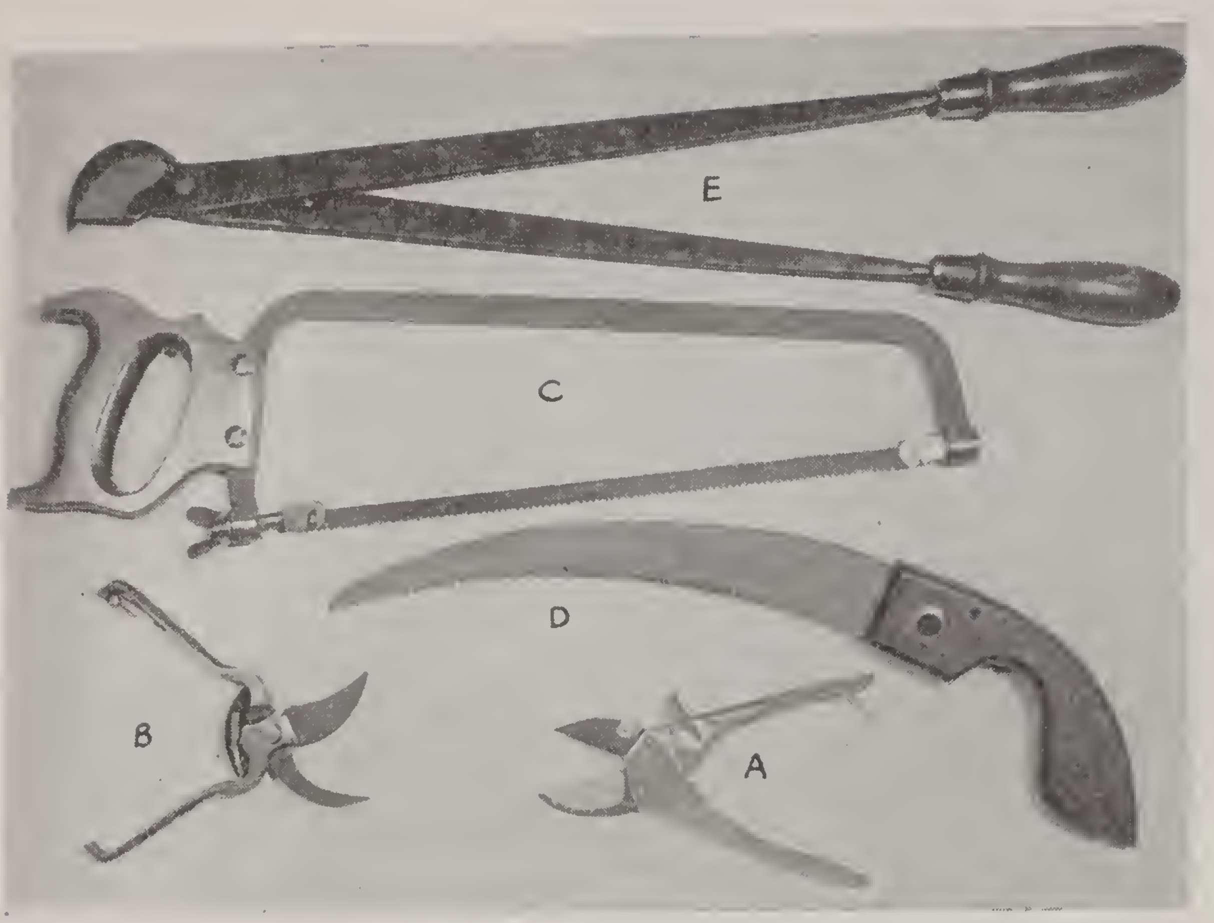
[1] For information contact Miller-Robinson Company, Los Angeles 1, Calif.; Poweraire Corp., Chicago 4, Ill.; or Orkil Inc., Hartford 1, Conn.



F. H. Beach, Ohio State University Agr. Ext. Serv.

Figure 38. Pruning tools. The "roll cut" hand shears, *A*, are convenient for cutting small twigs and particularly for detail pruning on mature trees. Hand shears, *B*, make snug cuts for all light pruning. The swivel-bladed saw, *C*, makes a close cut in narrow crotches and at difficult angles. "Half-moon" saw, *D*, cuts on the pull stroke and works fast on larger limbs but does not make as smooth a cut. Steel-handled lopping shears, *E*, are indispensable for mature apple trees where limbs over an inch in diameter must be cut. Take special care in placing the blade of these shears against the supporting limb in order to make a snug cut.

In removing branches, large or small, make the cut close and parallel to the supporting limb, as shown in Figure 39. Stubs do not heal and result in decay which may eventually enter the trunk of the tree and weaken the entire structure if the cut has been large. Stubs are the sign of an inexperienced and poor pruner.

Use both hands wherever possible while prunning. Cut with one hand and hold the limb to be removed with the other, steadily pushing the limb away from the blade as the cutting proceeds. Less "fist" strength is required with hand shears when the cutting is done in this manner. In using hand or lopping shears, place the cutting blades at the side or below the crotch (but not in the crotch) to secure the best cut. One should never wiggle the shears through a cut because this results in a ragged wound and may spring the shears.

If the orchard has been properly trained from the beginning, there is little or no need for removing large limbs, which is a practice to be avoided as much as possible. However, there are times when this must be done and the following procedure is recommended. Use a saw, making three separate cuts. The first cut is made on the lower side of the limb two inches deep

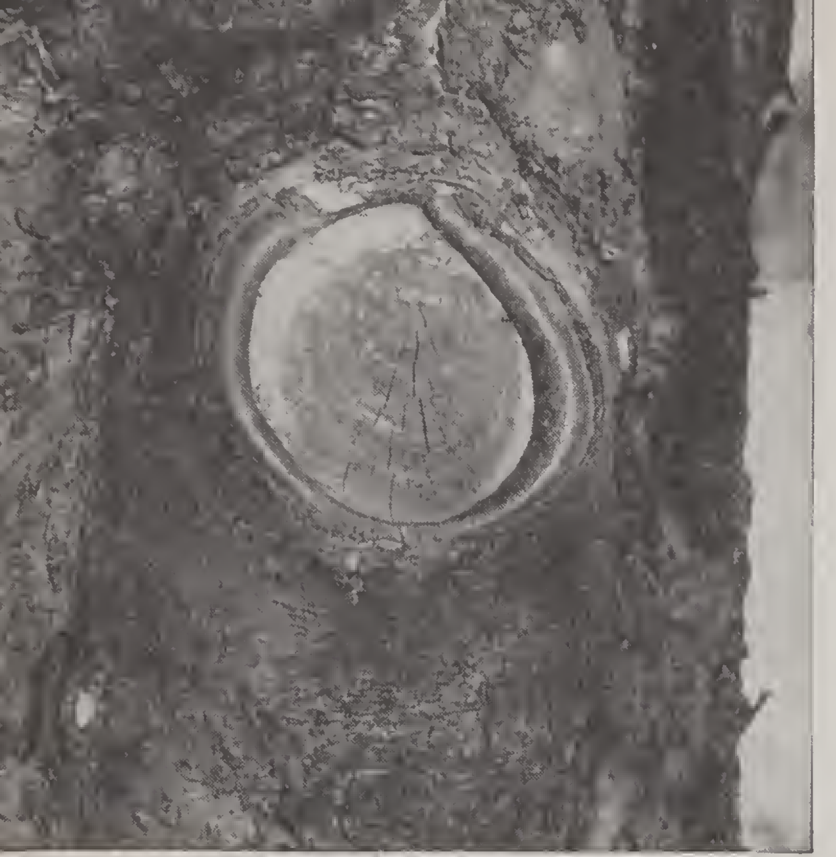


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Figure 39. This close smooth cut is properly made. Note that it is healing satisfactorily. Avoid leaving stubs when removing branches.

and about eight inches from the base of the limb. Thence, cut from above, starting about two inches closer to the base of the limb than the lower cut and continue until the limb falls. This prevents the limb from tearing bark or splitting down the trunk. The third cut is made close to the supporting limb to remove the stub.

Different types of cuts. Most everyone has noted that when a limb is removed from a tree, the shoot and spur growths are stimulated in the immediate vicinity of the cut. However, on a large bearing tree the growth and fruiting habits on branches not pruned are little affected by pruning cuts made elsewhere on the tree.

Heading-back pruning. The pruning cut shown at "a" in Figure 40 is known as a "heading-back" cut where the terminal growth of a main branch has been removed. In general, this is an undesirable practice because it discourages the normal development of lateral branches and spurs back of the cut. This is sometimes carried to an extreme on young bearing apple trees and results in numerous fast-growing vegetative shoots over the tree. Actually, many such cuts tend to dwarf the tree and retard bearing. There is also a necessity for considerable work in thinning out these branches later.

With young one-year trees in the nursery, this type of cut is commonly made by nurserymen in order to force side limbs out about 20–24 inches above the ground, so that the first side limb, chosen later by the orchardist, will be the proper height above the ground. Such cuts are necessary, also, on young trees which have made very long leggy terminal growths in order to get proper placement of lateral branches.

Thinning-out and bulk pruning. The term "thinning out" in pruning is employed where entire branches are removed. If these branches are large limbs, such pruning is sometimes termed "bulk" pruning. The principle behind this pruning is to admit more light and to remove unproductive branches which are producing few if any desirable fruit. There is usually little need for this type of pruning if the apple trees have received regular annual or biennial pruning attention. Bulk pruning is practiced only in very special and rare cases.

Thin-wood pruning. The term "thin-wood" pruning was first used by the

Michigan Agricultural Experiment Station, and it refers to the removal of slow-growing, weak, underhanging branches or spurs which are either not fruiting or producing fruit of low quality. Such wood is arbitrarily classified as any four-year-old apple wood less than one-quarter-inch in diameter at the base of the fourth-year annual "ring" (a group of bud scale scars where growth started each spring). The wood is said to be intermediate in vigor if it is four-year-old, has a diameter between one-quarter- and three-eighths-inch in diameter; and it is productive or thick in diameter if over three-eighths-inch near the base. Data from Michigan show that the thick apple branches produce at least ten times as many desirable apples as the thin-wood branches. Varieties differ in the amount of thin-wood they should be allowed to support. It will vary, also, with the location of this wood on the tree, and other conditions.

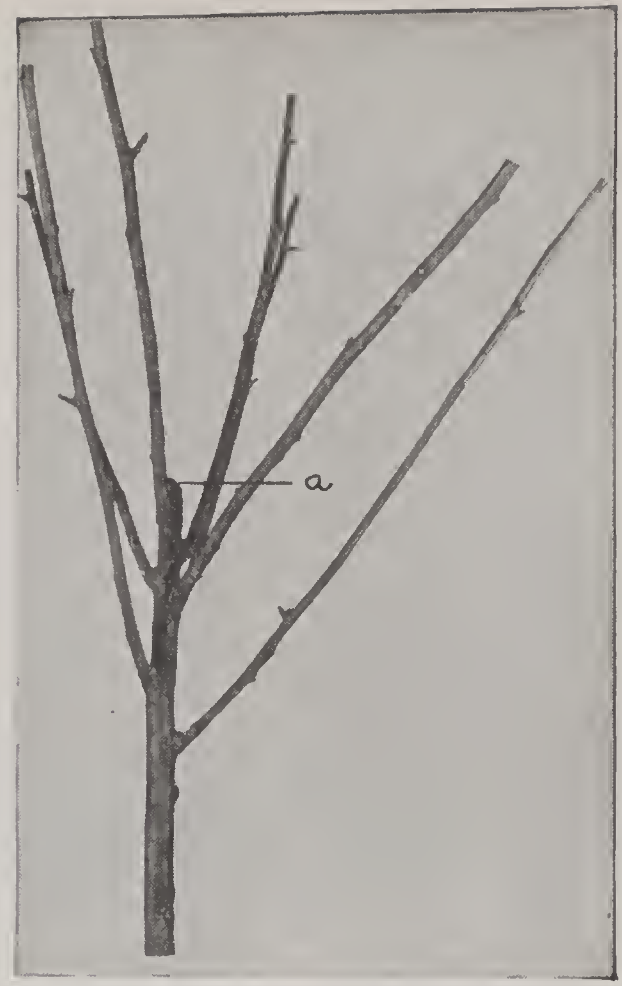

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Figure 40. A heading-back cut was made at a the year preceding. Note the excessive number of side shoots which have resulted. Such cuts are rarely advisable because they develop thick trees and considerable unproductive wood.

The brush pile should consist mostly of thin-wood and branches which are "fruited out" and poorly located. Thin-wood usually appears first on the oldest wood in the center of the tree and on branches nearest the ground. Thin wood can be detected best by standing next to the tree trunk at harvesting time and looking upward and outward and studying which type of wood is carrying the small poor-quality fruit.

Cutting to lateral branches. Many of the cuts in pruning are of this type. A limb is shortened by cutting to a lateral branch, making the cut in line with the side branch, as shown in Figure 43. The main objective of this type of pruning is to keep the sides of the tree within bounds and to lower the tops of tall trees so that they are within easy and more economical range for spraying, thinning, and harvesting (Figure 41). Also, branches that droop to the ground, or, those which grow closely parallel on top of other limbs are often cut back by this method to an upward- or outward-growing lateral. Such cuts do not dwarf the branch as much as heading-back cuts, nor do they induce many side branches to appear, and this is particularly true if the lateral shown at "L" in Figure 43 is almost the same size as the branch re-

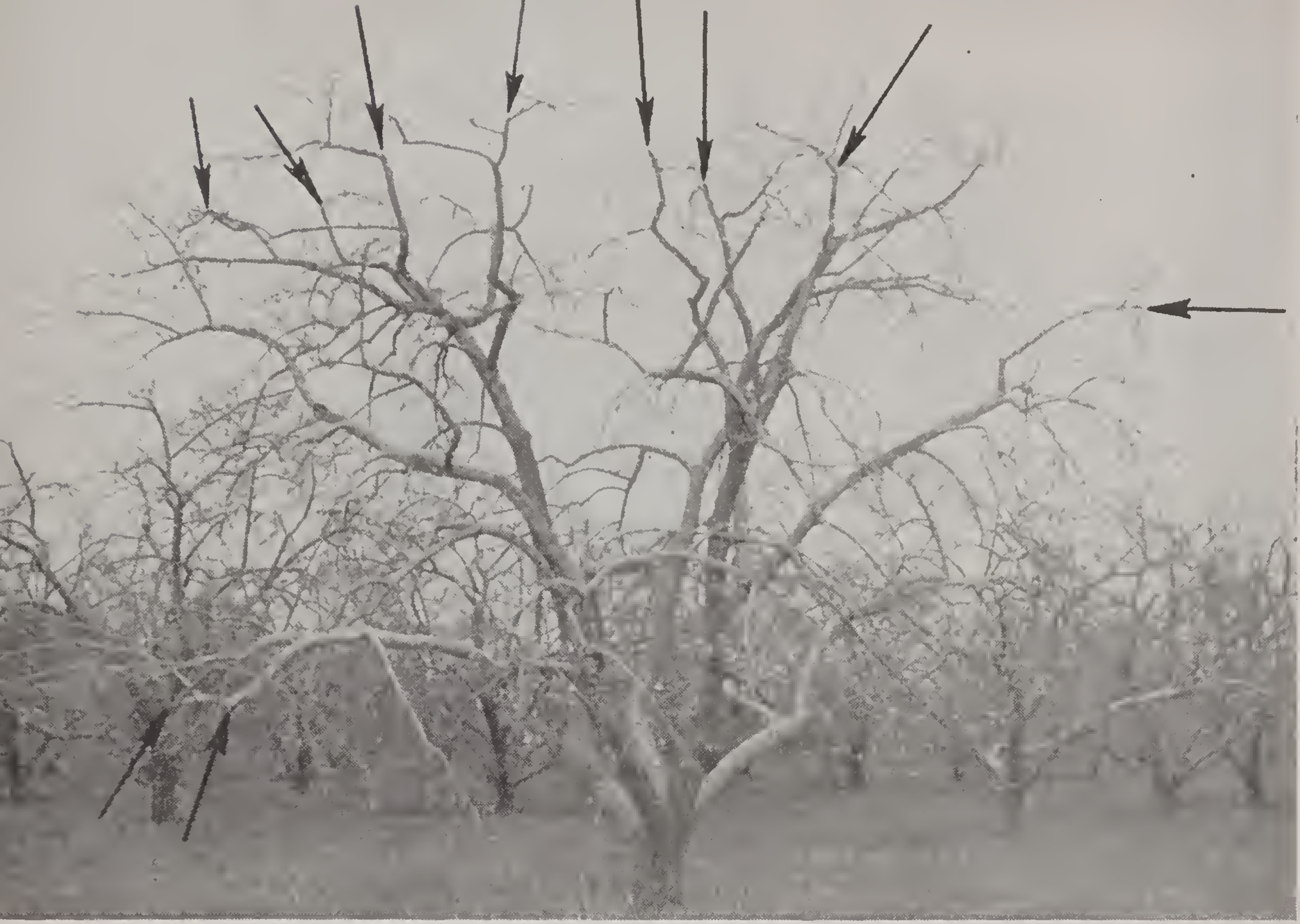

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Figure 41. Height of this apple tree is controlled by cutting back tall branches in the top to strong outward-growing laterals in order to keep the trees about 20 feet high. Lower arrows indicate where branches that drooped to the ground with fruit have been removed to upward-growing laterals.

moved. It is poor practice to remove a relatively large limb back to a weak growing lateral, as shown in Figure 44.

Detail pruning. This is a common practice and refers to the removal of small branches (not necessarily thin-wood) with the cuts well distributed over the length of limb. Both cuts in Figure 43 are classified under detail pruning. The main purpose is to prevent the small limbs, especially on the outer portion of large limbs, from becoming thick, crowded, and forming a more or less canopy over the center of the tree, shading it too much. A special advantage of detail pruning during the dormant season is that excessive flower buds and leaf buds are removed, thus improving the size and color of fruit developing from the remaining fruit buds. This pruning is particularly valuable when done in advance of an expected heavy crop. To some extent it takes the place of hand thinning of fruit in summer. The job can be overdone but, in general, moderately vigorous apple trees need a certain amount of detail pruning at least every other year. Detail pruning is often employed to a good advantage on certain varieties of apples that tend to develop too many fruits, resulting in small size and poor grade fruit. Popular varieties which tend to do this are Yellow Transparent, Golden Delicious, Rome Beauty, Jonathan, and Wealthy.

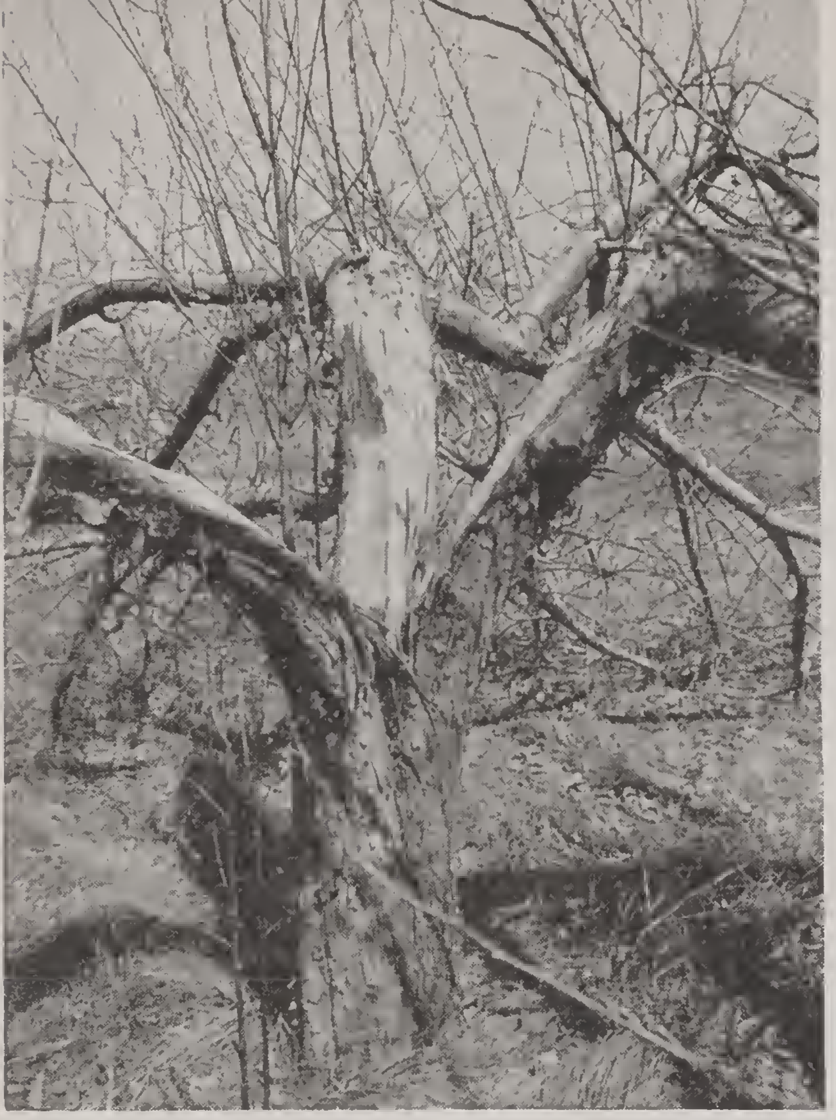

Figure 42. L. H. MacDaniels, Cornell University

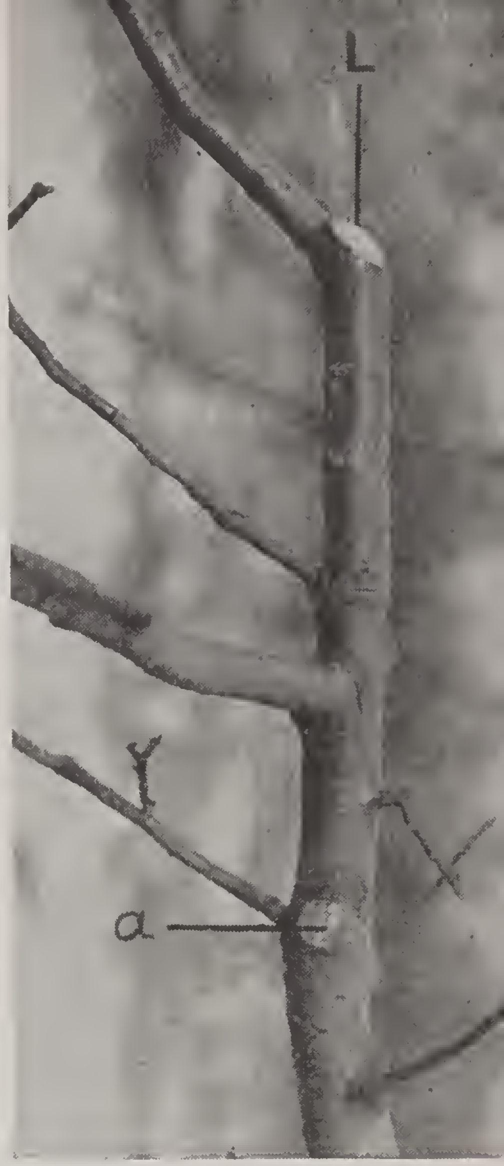

Figure 43. F. H. Beach, Ohio State University Agr. Ext. Serv.

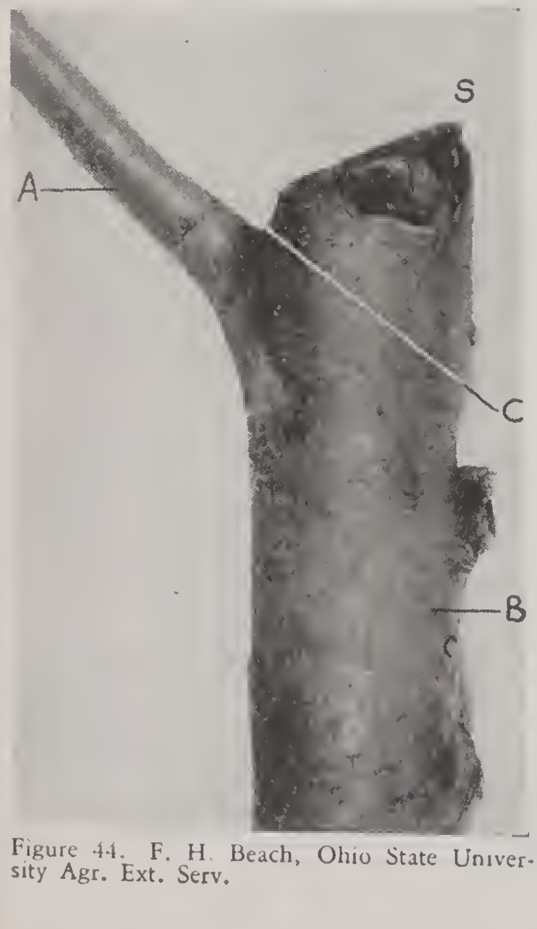

Figure 44. F. H. Beach, Ohio State University Agr. Ext. Serv.

Figure 42. A Baldwin tree split three ways with a heavy crop because of equal-size branches arising at the same point on the trunk. This is the result of improper training methods when the tree was young.

Figure 43. A limb is shortened by cutting to a strong lateral, as shown at *L*. This type of cut is used to keep a tree from becoming too tall or too wide.

Figure 44. The cut at *S* was not correctly made. It should have been made parallel with the lateral branch *A*, as shown at C. Note the high stub at *S* is dying back because it is above the line of active bark tissue which is supplying and being supplied by the leaves on lateral *A*. Lateral *A* is too small a limb at which to place a cut for a limb as big as *B*.

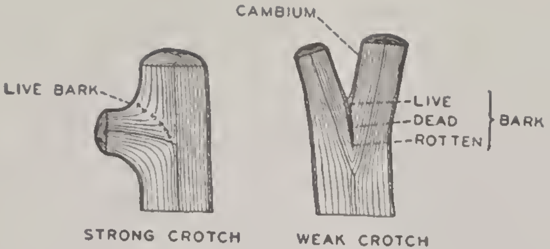

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Figure 45. *Wide-angled crotches are capable of bearing heavy crops of fruit without breakage.* In the strong crotch on the left, note the relatively thick seven successive layers of wood laid down by the cambium (active tissue in the bark). Compare with the weak crotch on the right. Note that the bark of each layer in the crotch angle comes together before the crotch is filled with woody tissue. These are known as bark inclusions which prevent a proper union and encourage decay. Such a crotch is more susceptible to winter injury.

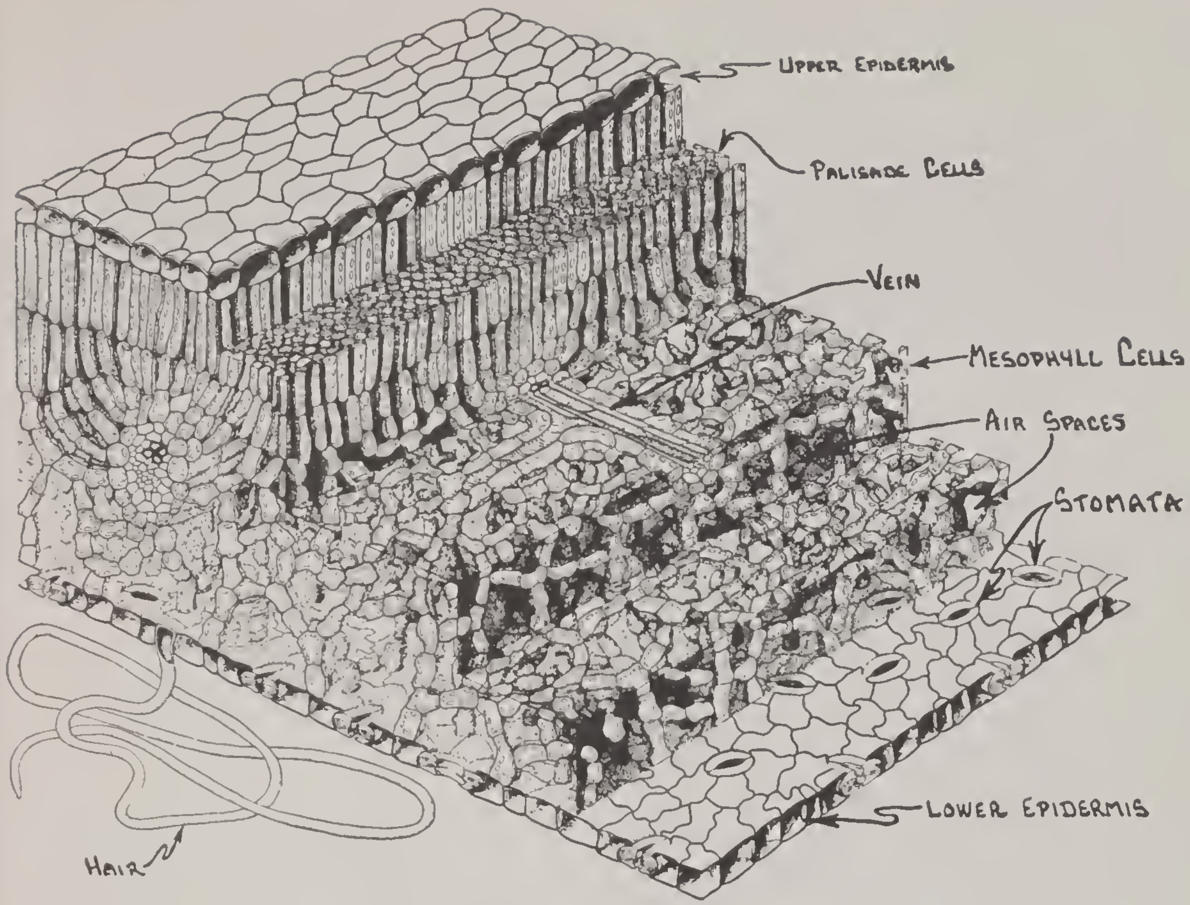
Correction of weak crotches. Figure 42 shows an apple tree which has split apart as a result of three limbs of about equal size being allowed to develop with narrow-angled crotches. It is important that no side or scaffold branch be permitted to develop as fast as the central leader limb. If a fast-growing side branch has a wide angle in the crotch, is properly located, and worth keeping, its rate of growth can be checked by pruning it back and thinning out the remaining laterals. Such pruning will assist in dwarfing it to a lateral, and permitting the leader limb to grow upward and six to eight inches ahead of all side limbs.

One should encourage side branches that leave the trunk at a wide angle, approaching 90 degrees, as shown at the left in Figure 45. Carefully note the structural difference between the right and left crotches in this figure. Poor crotches are a common ailment in most orchards and result in the loss of too much valuable bearing space when the orchard is at peak production. These situations can be avoided be careful annual training when the trees are young.

Treating pruning wounds and cankers. Wound dressings are needed only for cuts larger than about two inches in diameter. The sun is probably as good a disinfectant as any for the smaller cuts. There are several good wound dressings on the market which should be applied only to the exposed wood and *not* to the bark or healing area. A satisfactory cheap antiseptic paint can be prepared by mixing powdered bordeaux spray with raw linseed oil to the consistency of paint and applying it while fresh. Asphalt paint, grafting wax, and shellac also can be used. Water asphalt emulsions are inexpensive and effective, but precaution must be taken to avoid those containing toxic substances. "Flint Kote Static" and "Foster's I.B.M." are two good brands in Michigan.

In case of large diseased cankers on limbs and trunks, make a cigar-shaped or pointed cut which reaches live bark on all sides. Cuts through the bark should be vertical, not sloping, because the latter retards healing. Wound dressings should be made during the dormant season, preferably in March or April, together with necessary top-working and bridge-grafting.

In case of cankers of fire blight, bitter rot, and black rot, those limbs should be removed which are dead or have been two-thirds or more girdled by the disease. Such diseases are easily spread from one tree to the next by carry-over cankers. The blighted limbs should be removed back to a lateral, if possible, at a point at least six to eight inches below the diseased areas.



L. H. MacDaniels, Cornell University

Figure 46. A cross section of an apple leaf magnified many times, showing the principal parts. Food materials for tree growth and fruit production are largely manufactured in the leaves. Heavy pruning should be avoided because it reduces the "manufacturing centers" (leaves) of the tree.

In case of fire blight, it is not necessary to remove the smaller cankered areas if a special antiseptic solution is applied.[1]

Effects of pruning on growth and production of young trees. Before making cuts on a young apple tree, it is well to consider the following basic points. There is a close relationship between the activities of the roots and the activities of the leaves of fruit plants which must be considered to understand the results from pruning. The raw materials used by the leaves in manufacturing the tree's food supply come from the soil and from the air. The water and essential mineral nutrients are absorbed from the soil by the roots. From the air the leaves absorb carbon dioxide through the open stomata (Figure 46). In the leaves, largely among the mesophyll cells, the carbon dioxide from the air and the water from the soil combine in the presence of sunlight and green coloring (chlorophyll) to form starches and sugars. This process is known as photosynthesis. The mineral nutrients from the soil

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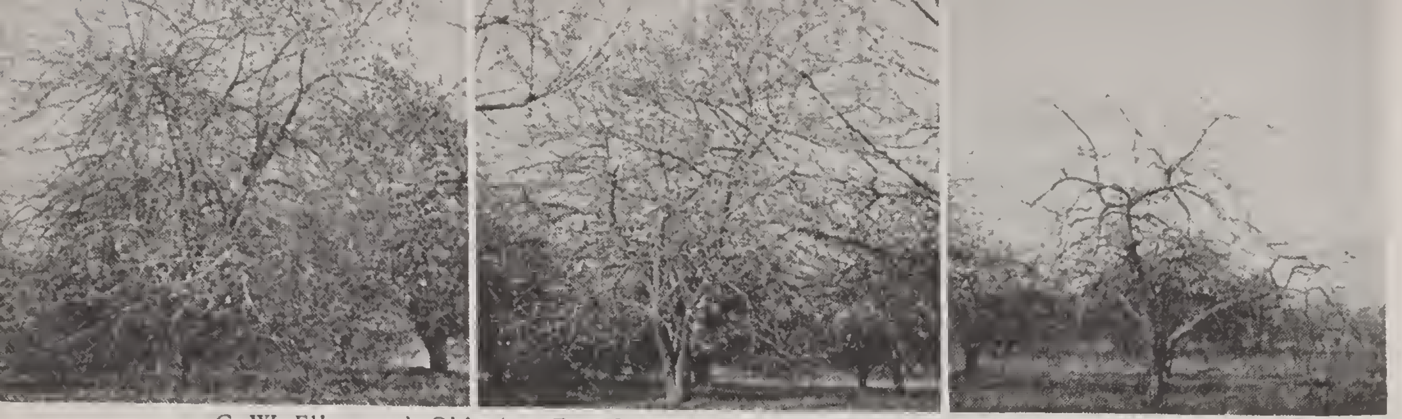
[1] Apply the following antiseptic solution to fire blight cankers, using a small paint brush: Add one quart of hot water to four tablespoons of concentrated hydrochloric acid in an enamel kettle, and in this mixture, dissolve nine pounds of dry zinc chloride powder. Commercial grades of these chemicals can be secured at the local drug store. Add sufficient red or blue coloring, or any good dye, so that diseased areas can be checked for good coverage. After cooling, pour the above solution into seven pints of denatured alcohol and mix well. Store in tightly stoppered glass bottles or jugs to prevent evaporation.



C. W. Ellenwood, Ohio Agr. Exp. Sta.

Figure 47. *Pruning is a dwarfing process.* These 27-year Stayman Winesap trees show different growth responses following variations in pruning. The large tree at the left has never been pruned, the tree in the center has received moderate pruning, while the tree at the right has been given heavy annual pruning. Average yield in pounds per tree for the ten-year period, 1933-1942, was for the unpruned tree—553, for the lightly pruned tree—606, and for the heavily pruned tree—467. Fruit from the unpruned (left) tree was small with a large percentage in the low grades.

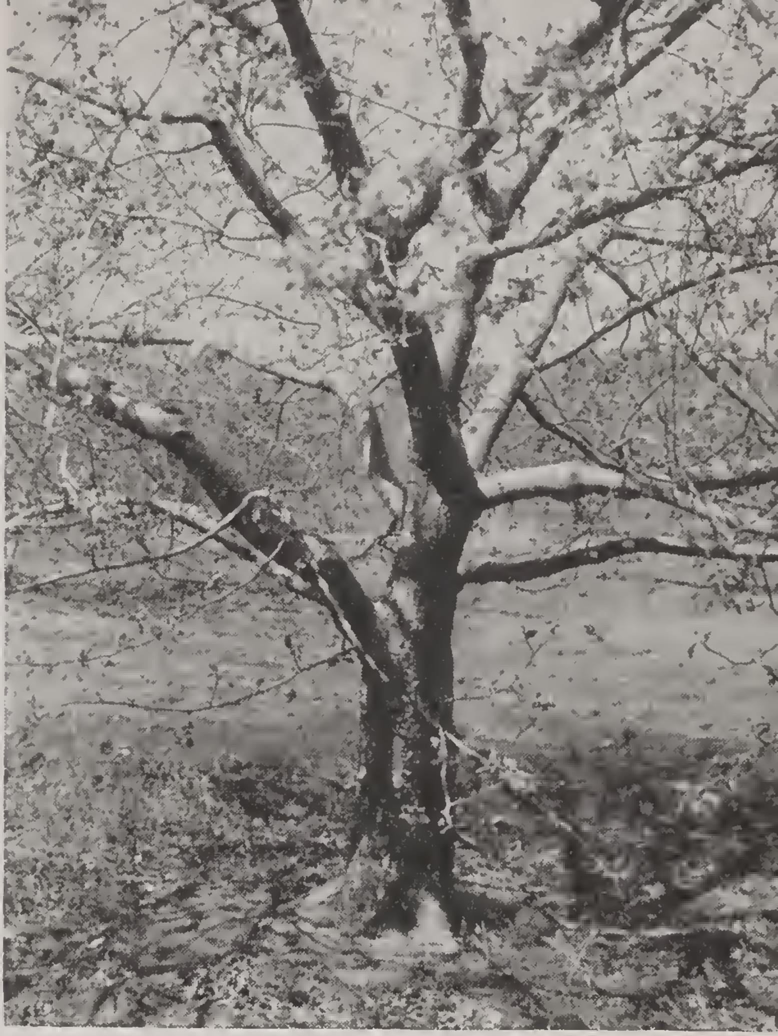
then combine with the carbohydrates to form the proteins and other plant foods which are used in the growth processes of the tree. The greater the amount of healthy leaf surface on a young tree, the faster it is capable of growing.

Pruning has a dwarfing effect on young trees. The greater the amount of pruning, the greater the dwarfing effect on the tree. This has been clearly demonstrated by many experiment stations (Figure 47) and has been readily seen in the orchards by fruit growers, themselves. As stated above, every leaf on a tree contributes food for the growth of the tree, and any removal of wood reduces the total leaf surface and the food-manufacturing power of the tree. It is true that one gains the impression that pruning stimulates shoot growth, but this stimulation occurs only within the immediate vicinity of the cut. Under these conditions, the top has been reduced in comparison with the roots and there is relatively more nitrogen and water available to the remaining shoots. Experiments have shown that the total shoot growth for all terminals over a pruned tree, however, is less than if the tree had not been pruned. This effect is accumulative and after a period of four or five years with young trees, it is clearly evident that the unpruned trees are larger than the pruned trees, depending upon how much pruning was done.

With young trees, only enough pruning should be done to accomplish the necessary training. *Every unnecessary cut is an economic loss to the grower.* Heavy pruning of young trees delays bearing for two or three or more years, depending upon the intensity of the pruning. Light annual pruning, only for the purpose of training the tree, however, has little effect in delaying bearing.

TRAINING YOUNG APPLE TREES

The ideal tree. It is necessary to have a standard or goal in mind as to the ideal arrangement of limbs on a tree before beginning to prune; otherwise, the cuts will have neither rhyme nor reason, and the ultimate result will be worse than if the tree had not been touched with pruning tools. It is generally agreed among horticultural specialists and growers that the *modified-leader type* of tree is the strongest and easiest to manage for the apple and most other fruits. It consists of a central trunk around which scaffold or side branches, of the desired number and spacing, can be arranged, as shown in Figure 48. It is difficult to point out an ideal tree-framework in the orchard, but the one shown in Figure 48 is quite satisfactory. Note that there are about seven scaffold branches arising from the central leader trunk. This is about the right number of scaffold limbs for a mature bearing tree. Note that the leader has been "modified," or cut to a side limb, at about eight to ten feet above the ground so that it no longer grows straight up but has been diverted outwardly. By so doing, the tree will be kept relatively lower and within better reach of the spraymen, the pickers, thinners, and the pruners. Also, the top center of the tree has been opened for light to enter throughout the inside and lower portions of the tree. Note that the lowest scaffold limb is about 20 to 24 inches from the ground and that the other scaffold limbs are spaced vertically about six to ten inches apart. Also, the limbs are well placed around the central leader limb so that each has a definite section of the tree into which it can grow.



R. J. Barnett, Kansas Agr. Exp. Sta.

Figure 48. A well-developed scaffold system on an apple tree trained to the modified-leader system. Note the open top, wide-angled crotches, and well-spaced scaffold limbs.

The variety of apple in Figure 48 has a spreading growth habit. Some varieties such as Yellow Transparent and Northern Spy tend to grow upright and it is somewhat more difficult to attain the desired framework. However, regardless of the variety, one should strive to attain as nearly as possible the more or less ideal tree pattern.

A special training system. An apple grower near Cleveland, Ohio, has developed the so-called "four-leaf clover" training and pruning system which he has used successfully for more than 20 years over some 200 acres of commercial orchard. The system has merits worth considering. The trees are trained into four quarters so that by the time bearing commences, there are two open channels one and one-half to two-feet wide through the trees from

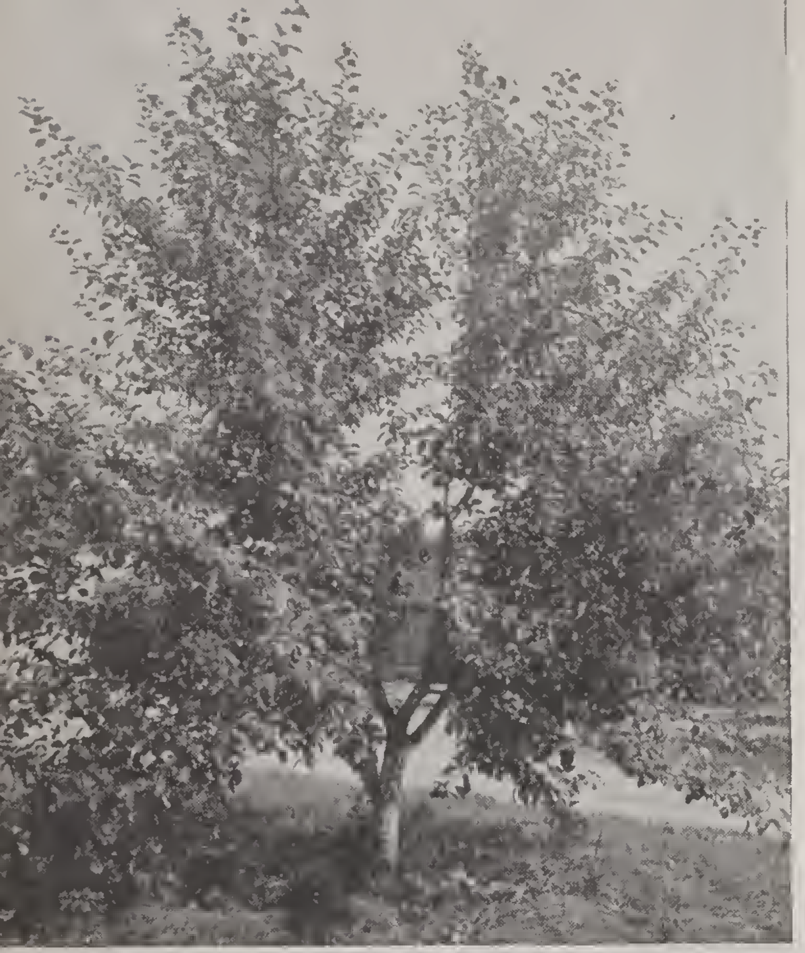


Figure 49. A 9-year McIntosh tree trained to the "four-leaf clover" system. Two open channels are being maintained at right angles through the center of the tree, dividing it into four quarters. It is essentially a modified-leader tree with two open channels at right angles.

northeast to southwest and from northwest to southeast (Figure 49). In this case the rows run east and west. Each quarter of the tree is comprised of one to three large branches which are pruned at maturity according to the needs of the variety. There are several advantages of these open channels through the trees. Light is readily admitted to the centers and results in more vigorous spur growth and better bearing throughout the quarters. Due to the fact that the channels are uniformly placed in each tree, the spraymen can systematically and more or less automatically direct the swirling spray into these holes and effectively cover all sides of the fruit. As a result of more light in the middles of the trees and good spray coverage, over 90.0 per cent of the fruit falls in the U. S. Fancy and U. S. No. 1 grades. The thinning, harvesting, and pruning operations are also facilitated because stepladders can be placed in the channels. This method of training trees has proven efficient and time-saving under the soil and climatic conditions of this orchard, and neighboring growers have begun to adopt it. Figure 50 shows a Baldwin tree which was converted to the four-leaf clover system at the age of 13 years, before which very little training or pruning had been done. It is important that this conversion be done over a period of four to six years, in order to avoid heavy pruning at any one time and the exposure of an occasional bare limb to the hot summer sun, resulting in sunscald. Very little trouble from sunscald, however, has been reported in this orchard.

Pruning one-year nursery trees at planting. Except for York Imperial, Jonathan, and a few other varieties, most varieties of one-year nursery apple trees do not have side branches. They come as whips, as shown in Figure 51.

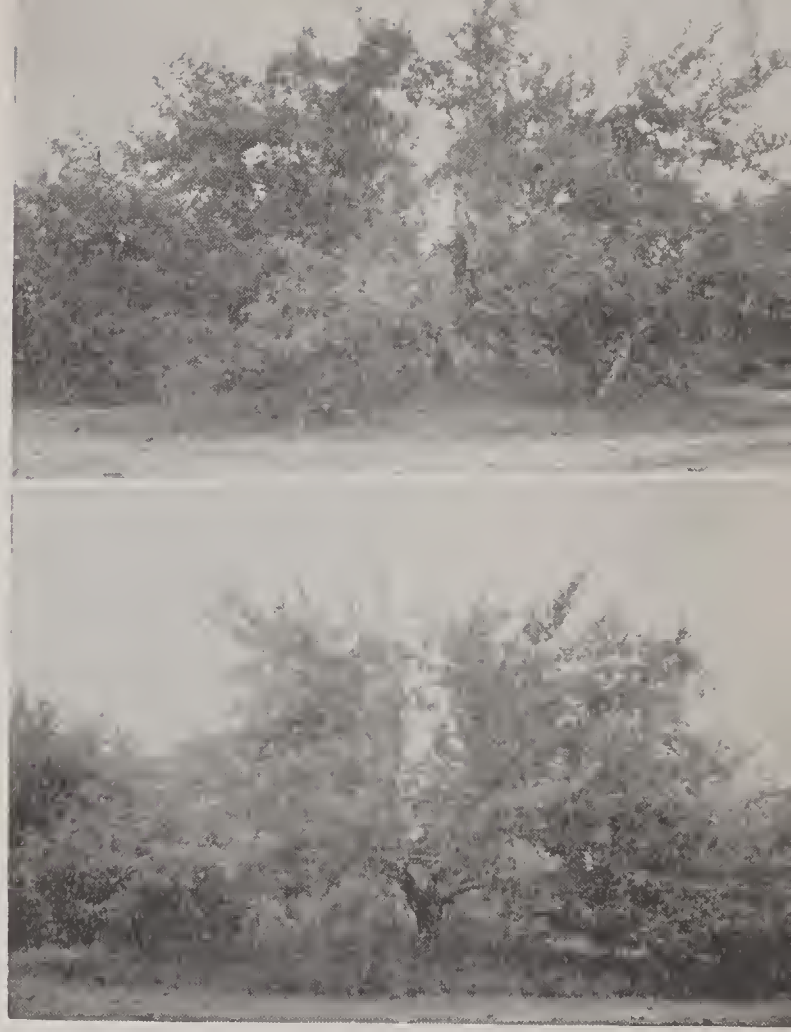


Figure 50. A mature Baldwin tree converted to the four-leaf clover system of pruning at the age of 13 years. The tree has been divided into four quarters by opening two-foot channels from northeast to southwest (top), and from northwest to southeast (bottom).

If the whips are more than five feet tall, the top is cut off about 50 inches above the ground immediately after planting. In early summer, when the lateral shoots are six to eight inches long, head the tree back again just above the highest desirable lateral which makes a wide angle with the trunk. If possible, this limb should be growing in the direction of the prevailing wind. The following spring, select about three additional side branches which leave the trunk at wide angles and which are well spaced around the tree and six to twelve inches apart vertically. It is preferable to have the lowest branch about 18 to 24 inches above the ground and on the side of the tree from which the prevailing wind comes.

If the one-year tree is less than four feet in height, head the tree back to about 30 inches above the ground at planting time, cutting back again in early summer to the highest desirable lateral as described above. These smaller trees are less desirable than the tall ones, but sometimes it is necessary to use them. As the tree develops, additional scaffold limbs can be selected from the main leader in the second or third year, or as they become available.

Deshooting one-year nursery trees. In recent years, some attention has been given to training one-year nursery trees by the deshooting method. After planting, the one-year trees are cut back as described above. When the leafy side shoots are about six inches long in early summer, select well-spaced, wide-angled shoots which will develop into a desirable scaffold system (Figure 52). Remove the undesired shoots. It is preferable to have the lowest branch on the southwest side or toward the prevailing winds. Where possible, in this case, the second branch is preferred on the southeast side; the third on the northwest; and the fourth continuing the trunk into a northeast scaffold branch. This provides a main scaffold branch for each quarter of the tree. It is desirable to have from eight to twelve inches of vertical distance between the wide-angled scaffold branches. It may take longer than one year to select the main scaffold limbs for a desirable system. With careful attention the first two or three years, some excellent scaffold systems can be developed by using this training method. Experience of the Ohio Agricultural Extension Service has shown that trees tend to be remarkably uniform in an orchard from the standpoint of placement of scaffold limbs (Figure 53). With some varieties subject to weak crotches, this method of training may result in some narrow-angled crotches. Under these conditions, the limbs which have narrow-angled crotches can be tied down, or, a stick can be used to spread the crotch for a year. The deshooting method is a definite improvement over the "disbudding" method originally used, where the buds were removed shortly after they "broke" in spring, and the three or four remaining shoots grew so rapidly that narrow crotches were often formed. The advantage of the deshooting system is that all buds and shoots are allowed to compete with each other for water and food materials for one to two months; and, therefore, they make slower growth and tend to develop wider-angled crotches at the outset. Also, the more vigorous and desirable scaffolds can be detected by waiting for a period after growth starts.

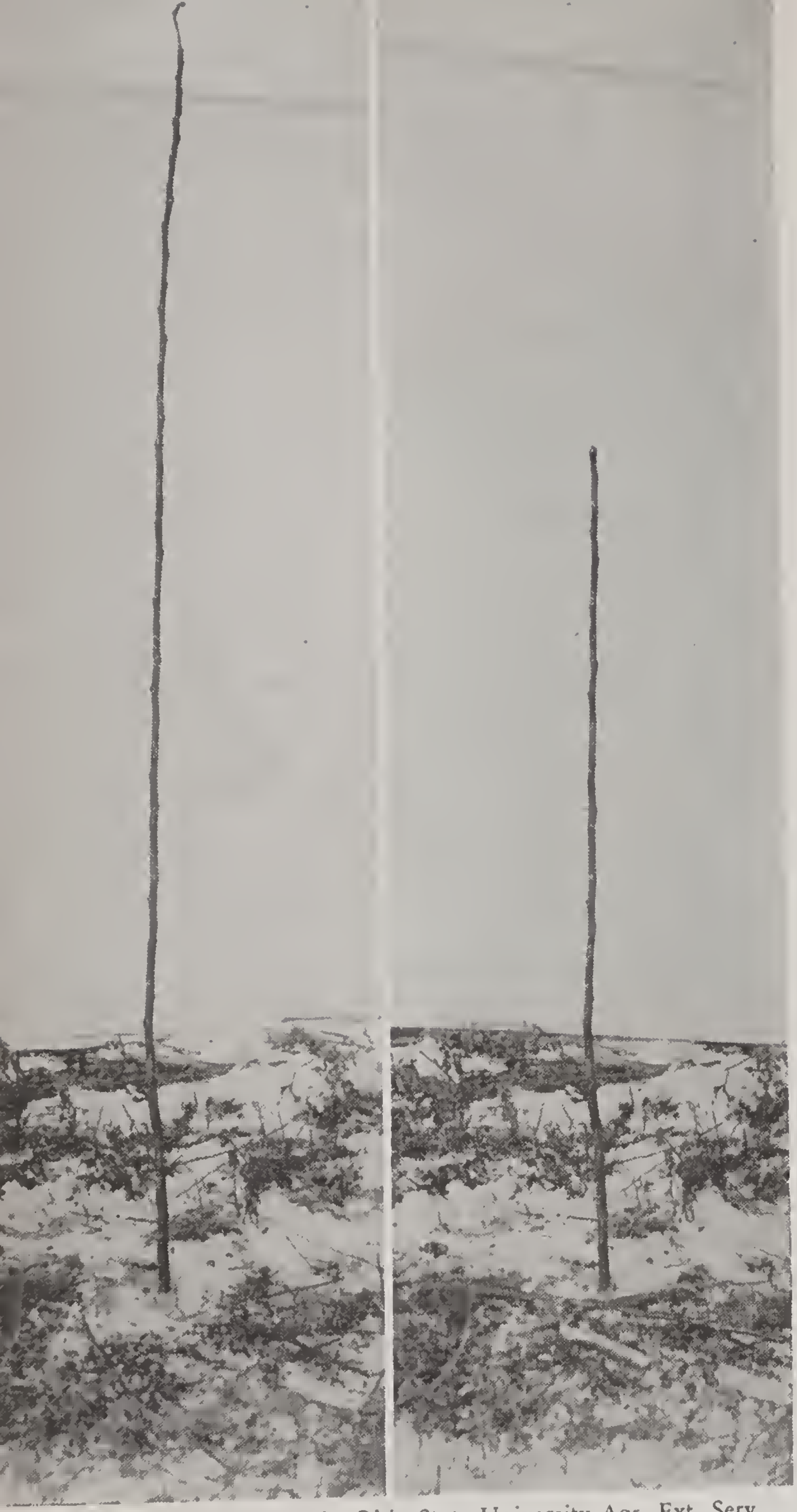


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Figure 51. (Left) A 1-year apple tree as it comes from the nursery before pruning. (Right) Same tree after pruning; top has been cut back to 30 inches. If the nursery tree is five to seven feet in height, cut back to about 50 inches.

Pruning two-year nursery trees at planting. The two-year apple trees have been headed back in the nursery to about 24 inches above the ground and they come to the grower as branched trees. There are usually several branches arising close together near the point where the tree was headed. Two or more of the branches may already be competing for the leadership, as shown in Figure 54. Select the best and usually the most vigorous branch for the leader and cut it back as directed above for the one-year-old whip; remove the other competing leader if its crotch is narrow; otherwise, cut it back one-third and reserve it for a scaffold limb if properly placed. If additional side branches are available around the tree at distances of six to twelve inches apart, they can be retained and pruned likewise. However, one rarely finds more than two desirable side branches on a two-year nursery apple tree.

It is specially urgent to remove as early as possible all side branches which form narrow angles or which are too close to other scaffold limbs. A side limb does not move upward from the ground as the tree develops. It is true, however, that as two neighboring limbs increase in circumference, they gradually come closer to each other. This is sufficient reason for wide spacing of scaffolds on young trees. The establishment of a desirable scaffold system on a tree is a gradual process and may require three to six years in order to get the desired vertical and radial spacing between limbs.

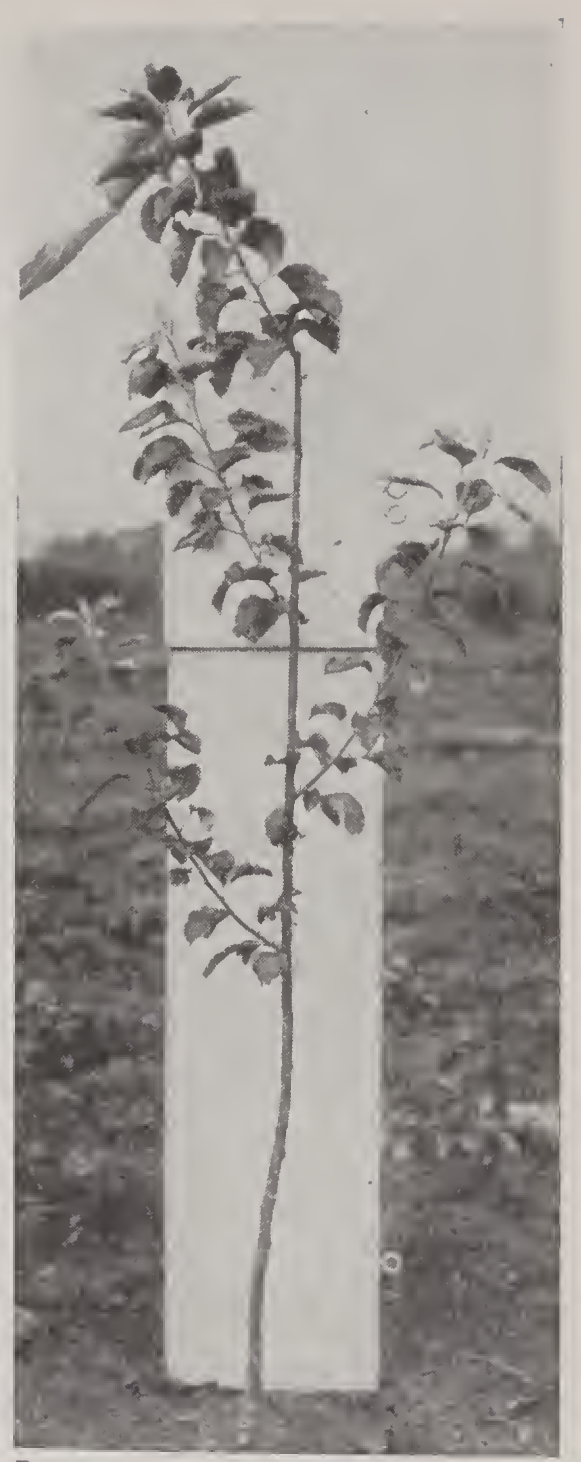

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Figure 52. A Stayman Winesap tree trained by the "deshooting" system, showing length and placement of scaffold limbs after one growing season in the orchard. The five and one-half-foot, 1-year nursery tree was cut back to the strongest growing shoot near the top when shoots were six to eight inches long about a month after growth started in the spring. Three additional shoots were selected below the top shoot, with first shoot about 20 inches from the ground, others spaced six to twelve inches apart at about equal distances around the trunk.

Pruning after one year of growth in the orchard. The pruner must continually bear in mind that *narrow-angled crotches* should be eliminated early. Therefore, with young developing trees, one must visit each tree at least once a year until the frameworks are fully established. Whorls of branches arising at about the same point on the leader should be reduced to one limb. The result of too many limbs arising at one place on the trunk is shown in Figure 44. Double and multiple leaders must be eliminated. This can be done by heavy pruning or removal of the limbs not selected for the single leader. No heading-back of lateral limbs should be done except when they are very long and unbranched, say in excess of 30 inches. Remove all water sprouts or limbs appearing at odd places on the trunk and at the base of the scaffold limbs. In general, very little pruning should be done on the secondary or side branches that arise from the scaffold

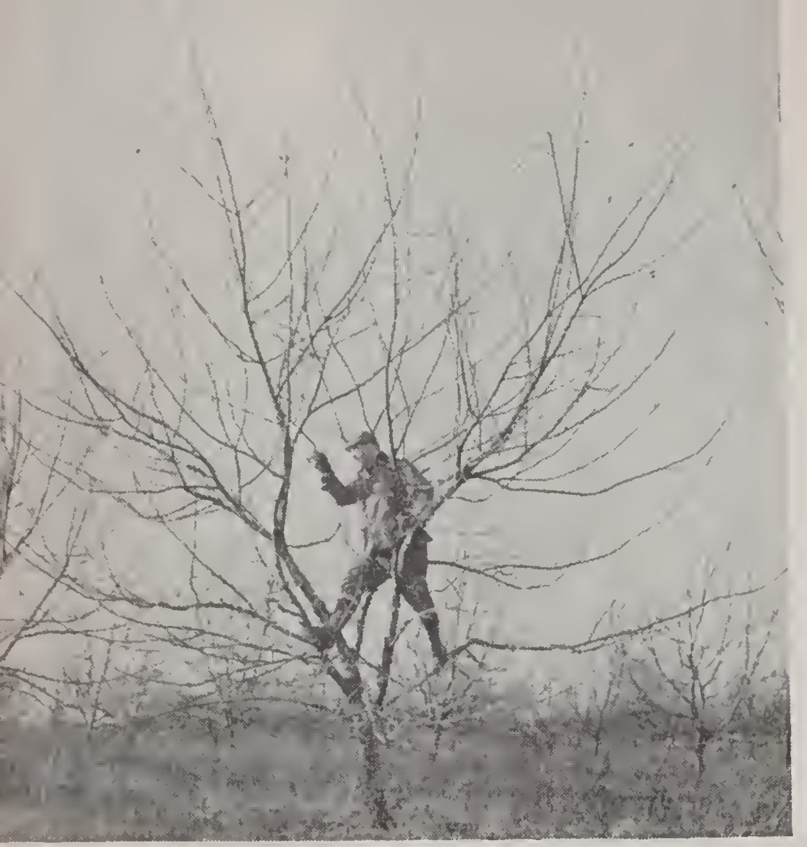

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Figure 53. A 12-year, standard-size Stayman Winesap tree showing strong framework development. This tree was trained at planting by the deshooting system. The orchard as a whole is remarkably uniform in good scaffold arrangement.

limbs. In this manner, pruning can be kept light and still accomplish the purpose of the training. This management will encourage early heavy bearing.

Subsequent pruning of young apple trees. The motto for pruning young apple trees might well be *"Prune lightly. If in doubt about a cut—do not cut!"* For the first eight years, one should concern himself primarily with the main scaffold and leader development of a tree. Leave the small branches and spurs on the young trees; they are the wood upon which the first fruit will develop.

Since every tree presents a different problem in pruning, nothing will substitute for common sense judgment in making cuts. For the beginner, it will be necessary to study the tree carefully before making, or, not making, the cut. After considerable experience, pruning becomes more or less second nature. Actually, it is a fascinating game.

The following suggestions are given for making the cuts on young apple trees:

1. Remove first the dead, cankered, broken or badly diseased limbs.

2. Remove as soon as possible (if they can be spared) branches which leave the leader at a narrow angle. These limbs are entirely unsatisfactory for permanent scaffolds.

3. Scaffold limbs may be found crowding each other. Either remove one or shorten it to a lateral that will develop away from the other limb.

4. Scaffold limbs may be found growing closely parallel, one above the other. If two limbs are concerned, the weaker, preferably the lower, is removed or dwarfed by heavy pruning, then eventually removed. If there are three limbs parallel one above the other, the middle one can be removed or heavily pruned. There should be a spacing of about four feet between scaffold limbs one above the other.

5. Avoid double leaders or whorls of limbs on the main leader and scaffold branches.

6. Remove water sprouts, unless they are needed to develop scaffold limbs in open areas of the tree. Sometimes, these water sprouts can be used to

form a natural brace for sharp-angled crotches which, unfortunately, have been allowed to develop.[1]

7. Keep the central leading limb growing about six to ten inches above all lateral limbs. At the age of six to eight years, modify the leader and begin to open the top by cutting the leader back to a strong side lateral. This should be done only after five to eight strong scaffold limbs have developed.

8. Side branches on the scaffold limbs should not be allowed to develop closer than about one foot to the trunk. Space other side branches on the scaffold limbs so that they ultimately will not interfere with each other. The less desirable branches are those growing toward the ground, straight up, or into the center of the tree. These are removed first, when thinning of wood is needed.

9. The lower limbs on the younger trees, being the oldest, come into bearing first and should be retained for fruit production as long as the fruit quality is satisfactory.

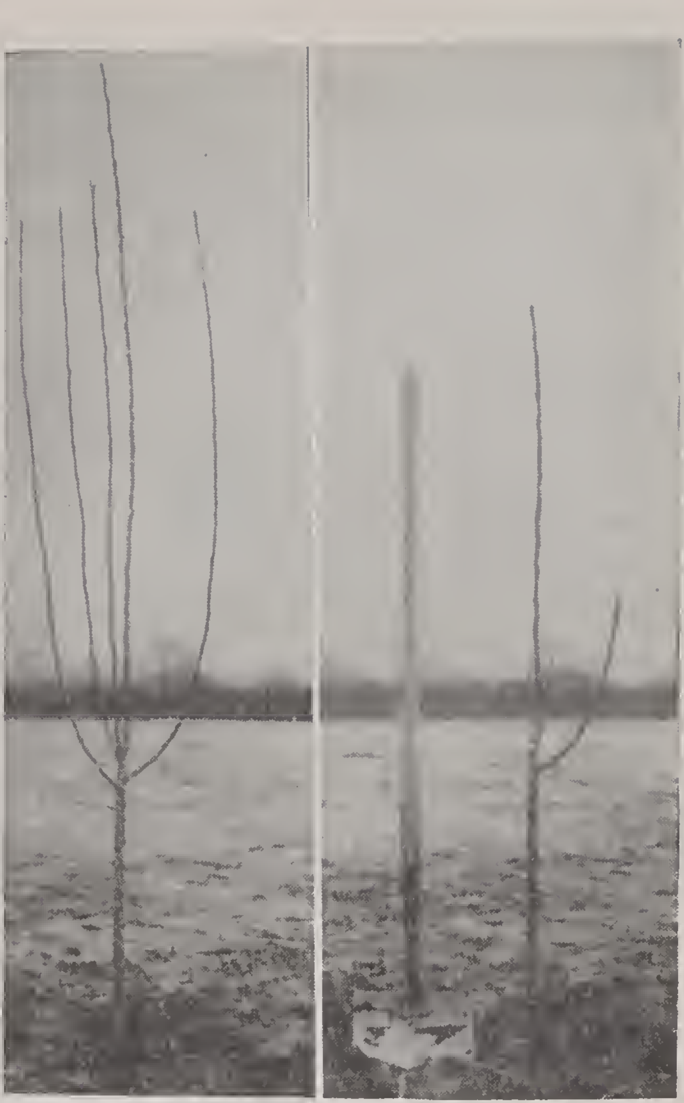

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Figure 54. A vigorous 2-year apple tree before and after pruning at planting. The largest and best of two central limbs was retained for the leader and cut back to about 50 inches above ground. The tree was planted with the best wide-angled lateral toward prevailing wind; lateral was cut back two-thirds. All other laterals were removed because they arose too close together.

Bending or tying down branches. Northern Spy, Yellow Transparent, Delicious, and other upright growing varieties are sometimes difficult to train because almost every main limb tends to grow upright. A special practice sometimes used is to train these branches into outward-growing laterals by

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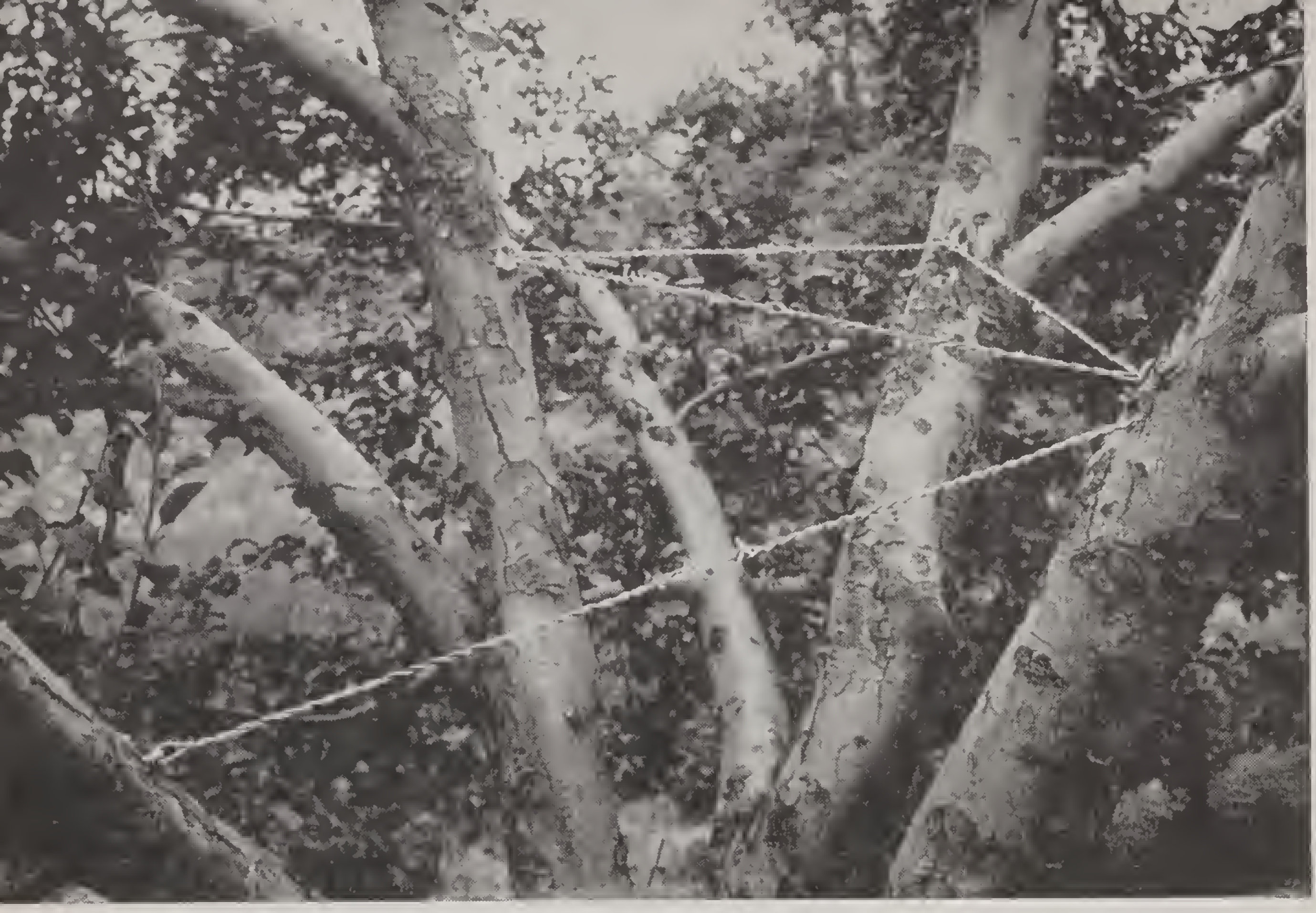
[1] Twine the water sprouts from each limb together and leave the terminal ends loose for a period of one or two years, after which they are removed. The brace grows together quicker and increases in size more rapidly if one sprout arises several inches higher than the other. These natural limb braces will increase in size and strength as the tree grows older. In case two water sprouts are not available, a single sprout can be inlay-grafted into the other limb as described later under grafting. It is important, however, that such a limb have plenty of "spring" in order that the swaying side limbs will not dislodge the graft.

The use of screw eyes and heavy wire, as shown in Figure 55, is probably the best and strongest method for bracing weak crotches of trees between 10 and 20 years old. For older trees, ring bolts are necessary in place of screw-eyes.



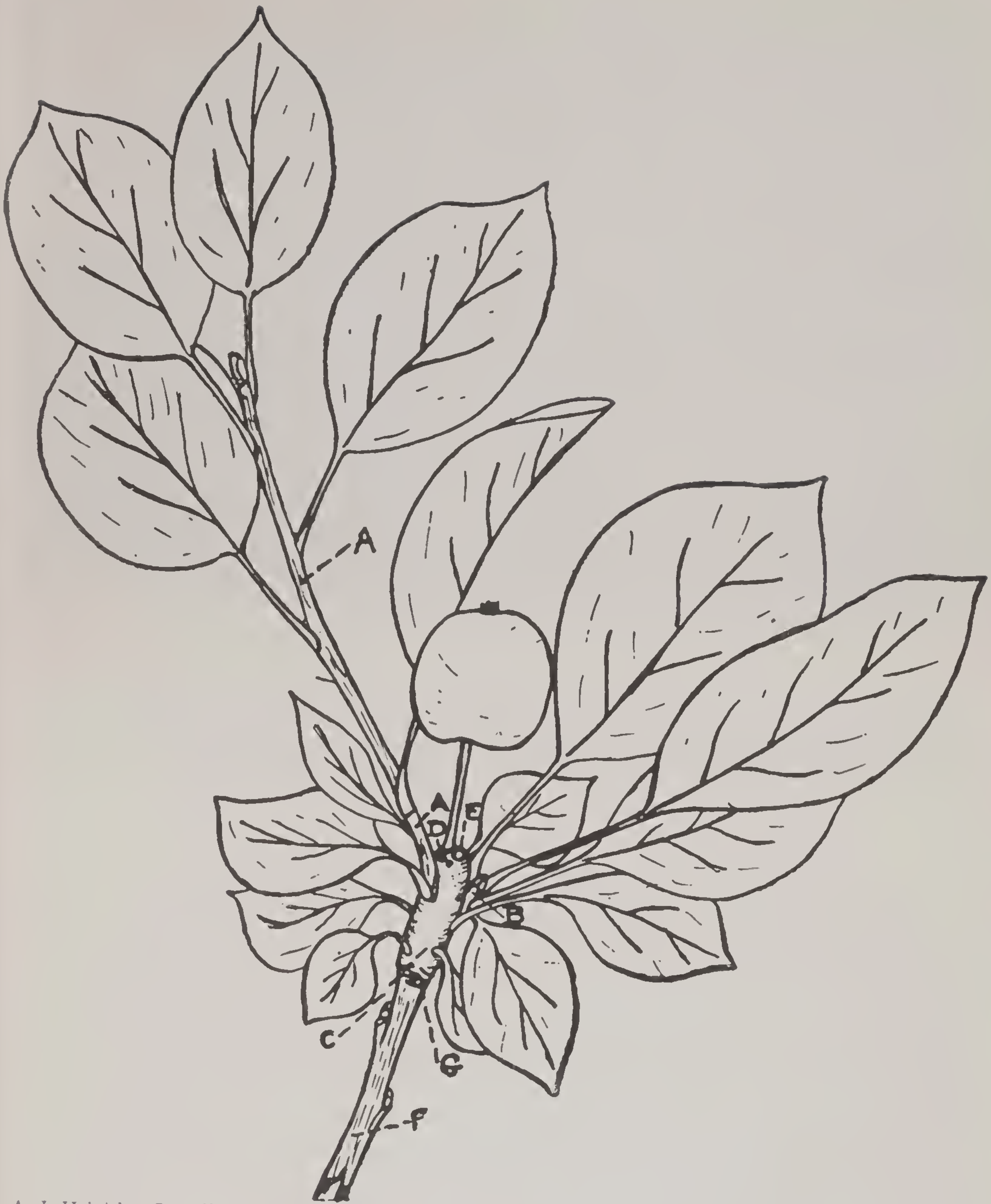
L. H. MacDaniels, Cornell University

Figure 55. Wire bracing is effective in preventing breakage of narrow-angled crotches. Large screw eyes with number 9 or 11 wire are employed, placing the brace preferably about two-thirds of the distance from the crotch to the end of the limbs.

bending or tying them down. This is done by driving a staple into the trunk near the ground and tying a piece of heavy cord or binder twine (never wire) from the staple to the end of the limb, using a loose loop on the branch. Fruit-bud formation will be encouraged on such limbs and they will be forced into earlier bearing. It usually requires a year to "fix" the branch in an outward-growing shape, after which the string should be removed if it has not already rotted away. Padded and notched sticks can be used in the crotches of young trees to spread the side limbs away from the leader, but this method is not as desirable or effective as tying down the limbs.

PRUNING BEARING APPLE TREES

Before pruning a mature bearing apple tree, it is advisable to briefly study the reasons for pruning and the ultimate effects upon the tree. The purpose is to increase the quantity of high-grade marketable fruit and to keep the tree within height and width bounds for more economical management. Pruning improves color, increases size of fruit, keeps the fruiting wood vigorous on old trees, and assists in controlling insects and diseases. With some varieties such as Jonathan, McIntosh, and Rome Beauty, the detail and thin-wood pruning will largely take care of the need for fruit thinning in July, and at less cost per tree.



A. J. Heinicke, Cornell University

Figure 56. A vigorous apple spur which has set a fruit and developed good lateral growth by early July. Note terminal buds have formed on lateral shoots at *A* and *B*. The large scar at *E* is from the stem of an apple that fell during the June drop; the small scars at *D* are where flowers were located that dropped at blossomtime. Part of the preceding year's growth is shown at *F*. Growth was initiated in late April at G. C refers to the cluster case.

Shoot growth. Shoots are defined as the leafy new growths on a tree; when the leaves on these shoots are lost in autumn, they then become "twigs." It is interesting to note that terminal and lateral shoot growth on a bearing tree are often completed within a few weeks after growth starts in spring (Figure 56). As the tree becomes older and begins to bear, there is a tendency for the length and diameter of the shoots to become less and less each

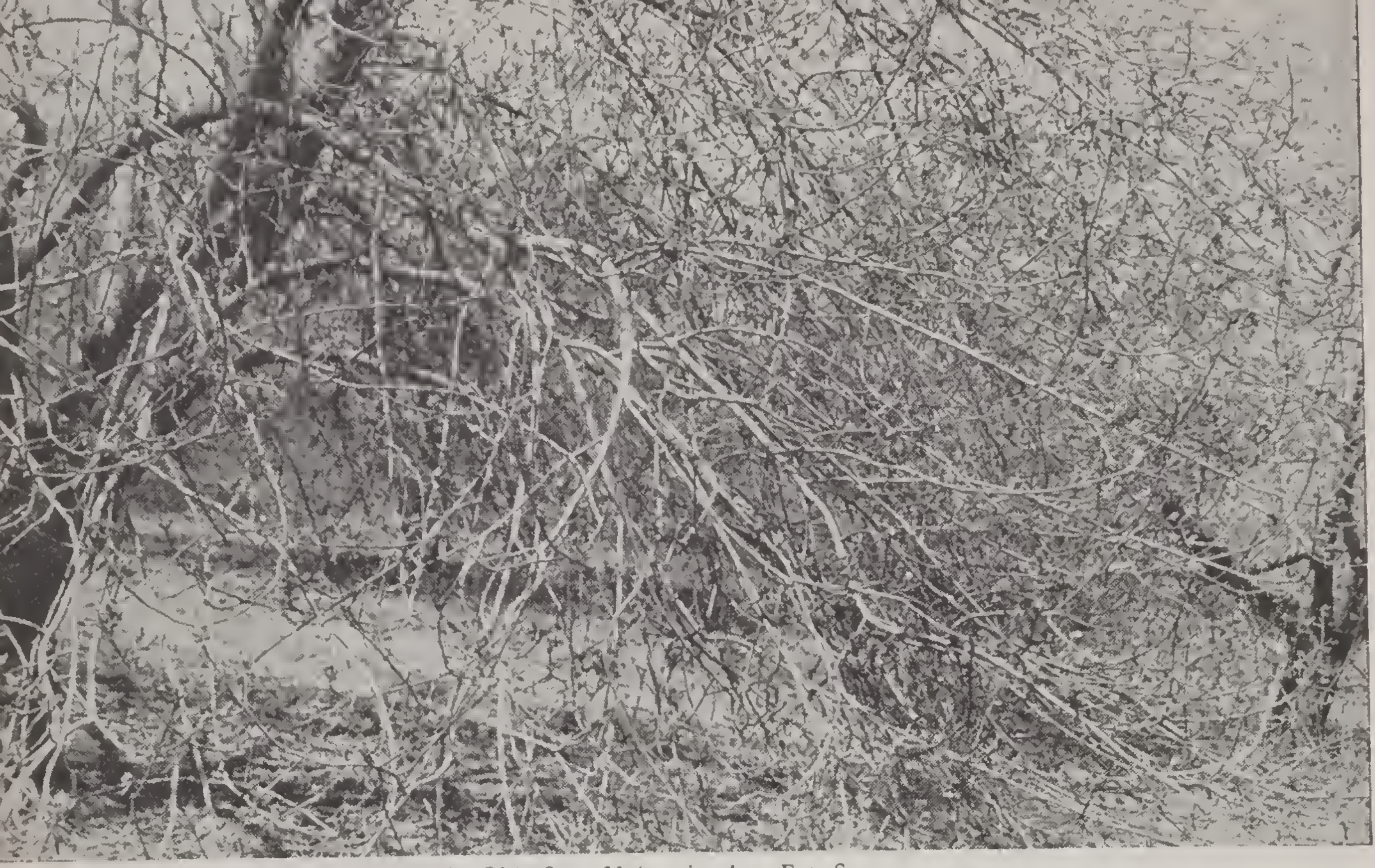


Figure 58. F. H. Beach, Ohio State University Agr. Ext. Serv.

Figure 57. A mature Stayman Winesap tree which has become dense and matted due to lack of detail and thin-wood pruning. This wood is heavily shaded and too crowded to spray thoroughly; it produces small poorly colored fruit. These branches should be thinned out over a period of two or three years until the density resembles that shown in Figure 58.

year. Pruning, together with fruit thinning and a desirable soil management program, then become necessary to control the kind and amount of fruiting wood in order that production of large-size quality fruit can be maintained. In case of young trees, it is desirable to get as much terminal growth as possible, often 24 inches or more per year, but at the same time properly ripen and mature the wood for winter (wood growing vigorously into autumn is likely to winter kill). With bearing trees, it is important to obtain plump terminal shoot growth of 10 to 15 inches in length on fruiting branches, with the longer 15-inch terminals desired for such light setting varieties as Delicious and Stayman Winesap.

Fruit spurs. The term "spur" refers to the numerous short growths which are abundant over the fruit tree and upon which most of the fruit is borne (Figure 56). Large thick spurs well-supplied with leaves are correlated with large well-colored fruit. Note the abundant leaf surface on the vigorous spur in Figure 56. In order to keep the spurs in a vigorous condition in older trees, some annual or biennial pruning is necessary with cuts well distributed over the tree.

The apple fruit bud, which contains both flowers and leaves, is usually terminal on the spur and when it sets a fruit, the new shoot growths are forced out from the sides as shown in the accompanying figure. This accounts for the fact that a fruiting spur has a zigzag growth. A nonfruiting spur, on the other hand, grows straight year after year because the terminal bud is always a leaf bud. Some varieties bear fruit terminally and/or laterally on last year's terminal shoot growth, in addition to bearing on spurs. Examples are Jonathan, Wealthy, and Rome Beauty.

An apple fruit spur usually bears fruit every other year. Pruning reduces the total number of blossoming spurs on trees which are heavily supplied with them, thus preventing overloads of fruit and inducing a more regular bearing habit from one year to the next. When too many growing points blossom and fruit at the same time, conditions are unfavorable for fruit bud formation during the early summer of the overload period.

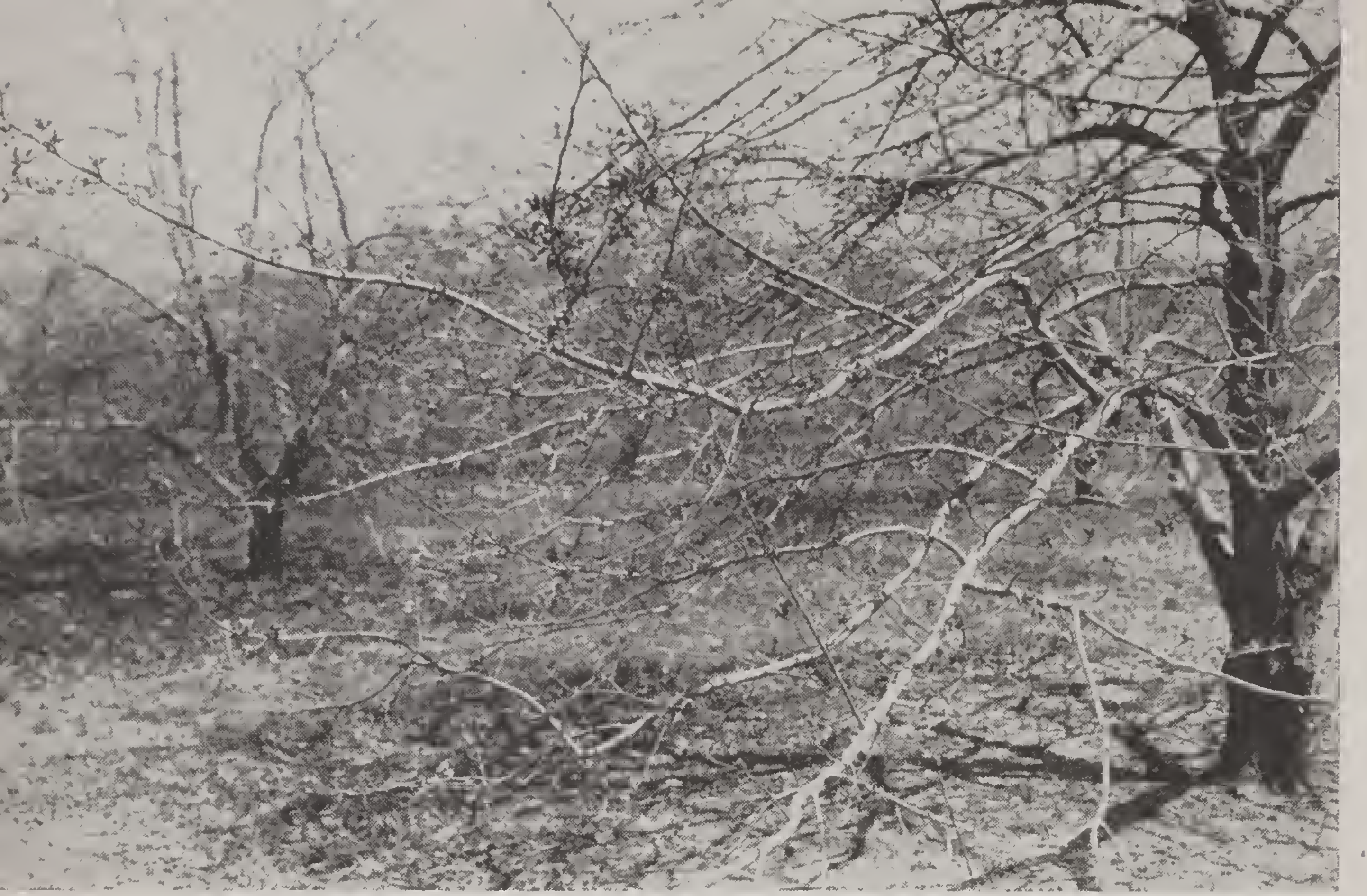
It is important that plenty of light reach the leaves on the fruit spur, for these leaves will manufacture a large part of the carbohydrates that go to form the neighboring fruit. Heavily shaded spurs with two or three small leaves rarely develop well colored and good-sized fruit. Figure 57 shows a dense mat of lower limbs which have not received pruning for five or more years. Naturally, the fruiting spurs in this area have, for the most part, become weak or died. It is important that such areas be thinned out over a period of two to three years until the more desirable situation is obtained as shown in Figure 58.

The varieties which will respond well to thin-wood pruning on mature trees include Rome Beauty, Stayman Winesap, Golden Delicious, Delicious, McIntosh, Cortland, Yellow Transparent, Jonathan, Wealthy, Rhode Island Greening, Baldwin, Northern Spy, York Imperial, and Mammoth Black Twig.

BENEFITS OF PRUNING MATURE TREES

Pruning increases fruit color. Sunlight to the inner leaves on a tree and to the fruit itself are highly essential for good fruit color. With proper pruning over the mature tree, sunlight will be admitted to the fruits and leaves throughout the tree. The leaves thus are able to carry on a higher rate of food manufacture. The sugars resulting from this manufacture are used in the development of highly colored fruit. During the ripening period, the fruit must be well supplied with carbohydrates, principally sugars, beyond the requirements for growth.

Pruning increases size of fruit. Judicial dormant pruning promotes the rapid development in size of fruit, starting immediately after the fruit is set in spring. Dormant pruning is more effective in obtaining size improvement in fruits than hand thinning in July, because by July considerable nutrients and carbohydrates will have gone into the fruits that are knocked to the ground by hand thinning. Thin-wood and detail pruning prevent this wastage of nutrients and food materials by diverting them to the better located apples. It is important that the pruning practice be interrelated with other practices, especially thinning, use of fertilizers, and soil management in order to secure the greatest response in size improvement. However, when



F. H. Beach, Ohio State University Agr. Ext. Serv.

Figure 58. Thinning-out cuts followed by thin-wood pruning on this Stayman Winesap have resulted in better admittance of light during the growing season. Size, color, and quality of the apples on the lower limbs will be improved; also thorough spraying can be done with less material.

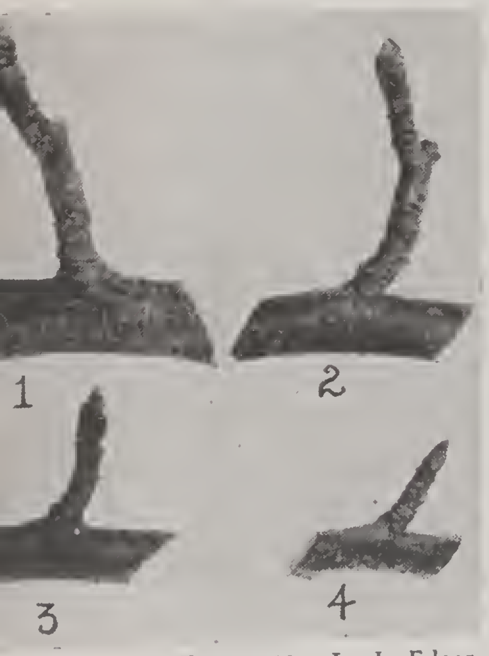


Figure 59. L. J. Edgerton, New Jersey Agr. Exp. Sta.

Figure 59. Four classes of Delicious spur buds ranging from strong (1) to weak (4). Subsequent records of similar buds showed for No. 1, 98 per cent bloomed, 73.6 per cent matured fruit; No. 2, 99 per cent bloomed, 48.6 per cent matured fruit; No. 3, 15 per cent bloomed, 5.5 per cent matured fruit; and No. 4, 4.0 per cent bloomed, 0.7 per cent matured fruit.

pruning is carried to extremes, it reduces yields. Considerable study, experience, and skill are necessary to prune and produce the highest yield of good size, color, and all-round-quality fruit.

Pruning keeps fruiting wood young and vigorous. Every orchardist has noticed the large size, good color, and fine quality of fruit which is borne on young trees shortly after they come into bearing. Pruning must be performed on mature trees in such a way as to keep the fruiting wood similar to the ideal growth conditions usually found in the young bearing trees. Essentially, this means that well-placed new growths should be encouraged, pruning them for a few years while vigorous and productive and then eliminating them when they become old, underhanging, and in the thin-wood class. Pruning on mature bearing trees, therefore, can be classified as a renewal practice of replacing old wood with new wood.

Pruning assists in controlling insects and diseases. If the tree is kept reasonably open, it is much easier to direct spray material into and through the tree. Effective spraying is highly important because it represents about one-third of the cost of growing apples. It is particularly desirable that the trees dry rapidly after rains. A dense matted condition of limbs prevents this rapid drying and encourages spray injury and such important apple diseases as scab, blotch, bitter rot, Brooks spot, and sooty fungus. It is necessary to hit the fruits with spray material on all four sides, not just one side, in order to control scab, codling moth, apple maggot, and bitter rot. Likewise, proper pruning reduces aphid injury and limb rub on the fruit.

STEPS IN PRUNING BEARING APPLE TREES

One of the chief objects in pruning mature trees, in addition to increasing the amount of quality fruit, is to keep the trees within height and width bounds. In recent years, there has been a tendency to maintain the tree tops low or about 20 feet or less, because low trees are much easier and less expensive to spray, thin, pick, prune, and manage in general. One of the common faults in pruning bearing apple trees is to leave a shell of unpruned branches around the outside of the tree and to remove too much inside and lower fruiting wood because it is the easiest to reach. The sides as well as the top must be kept open for free entrance of sunlight and spray material.

The following brief suggestions are given for making cuts on mature trees:

1. A good procedure is to start at the top of the tree and work downward, cutting upward-growing limbs back to strong laterals, removing the crowding branches, and thin-wood pruning the remaining limbs. Start as far out on the limbs as can be safely reached and prune back to the base, leaving the vigorous fruiting wood well spaced along the length of the limbs. By working from the top of the tree toward the ground, it is possible for the operator to remove the brush which hangs in the tree while working above. A step-

ladder or lean-to ladder will be needed to prune the high side branches and help keep the top open.

2. Remove dead, broken, and diseased wood. If dead wood is allowed to remain on apple trees from one year to the next, it harbors and disseminates such diseases as bitter rot and black rot (frog-eye).

3. Remove or dwarf by relatively heavy pruning any large limbs which are crowding other limbs, growing parallel with them, or resting upon them. Use judgment, however, in making the few necessarily large cuts so that direct southwest sunlight during hot days in summer will not sunscald remaining exposed branches.

4. Remove all water sprouts, except an occasional one which may be needed to fill a vacant space in the tree.

5. Where it is necessary to thin a thick side branch, the first cuts should be made on the under side of the limb where the weakest wood occurs. Next, thin out the "thin-wood" or badly placed interfering branches growing upward from the top of the limb. Then, thin the poorer wood which arises from either side of the limb. Divert branches to open areas and away from other branches by pruning back to desirable laterals. Be careful not to overprune.

6. Bearing trees can be kept in best condition by annual pruning or, certainly, by pruning every other season. This promotes regular annual bearing. If it is difficult or impossible to give the orchard a light pruning each year, the next alternative is to arrange the pruning so that it will be done preceding the expected heavy-crop years. Such pruning prevents blossom and fruit overloads to a large degree and reduces the labor expenditure in hand thinning of the fruit in July.

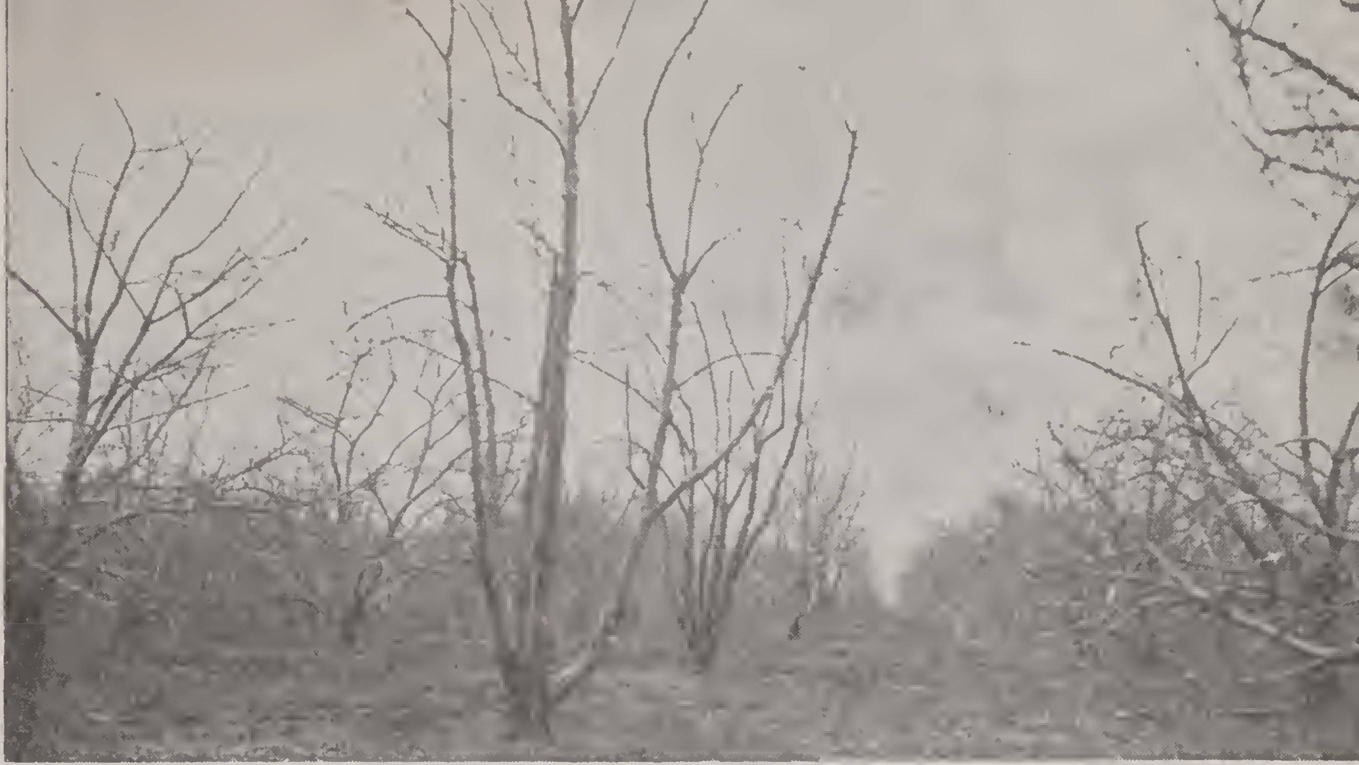
7. If pruning is irregular, or at intervals of four to six years, many trees grow out-of-bounds and develop irregular bearing habits, with undesirable excessive loads of fruit that further exhaust the tree during seasons which are favorable for heavy cropping.

8. There is less risk from winter injury when pruning is done in late winter and early spring.

9. For special pruning requirements of important varieties, see discussion on pages 88 to 90.

PRUNING FILLER TREES

As pointed out earlier, filler trees are planted between the permanent trees to increase the fruit production per acre before the permanent trees fully utilize the ground. Filler trees are usually retained from 15 to 18 years. Little or no labor should be expended in pruning these trees after the first two or three years in the orchard. Considerable experimental evidence is available to show that apple trees will bear more fruit of almost equally good quality when no pruning is given for the first 15 or so years, after which problems of limb breakage, poorer quality fruit, and others arise. However,



F. H. Beach, Ohio State University Agr. Ext. Serv.

Figure 60. Row of filler Wealthy trees is shown in the center; they have been pruned heavily on the sides or "fanned" to prevent interference with permanent trees on either side. Fillers can be cropped 10 to 12 times before they begin to interfere with permanent trees and *must* be removed.

as these fillers begin to crowd after the first 12 to 15 years in the orchard, heavy cutting back of the side branches is needed to assist the machinery in getting through the orchard and, also, to enable the permanent trees to develop symmetrically without the slightest crowding at any time. Filler trees on which this type of pruning has been practiced are shown in Figure 60. The heaviest cutting on these trees should be done preceding a big crop year. When an apple tree is carrying a good load of fruit, it tends to make less shoot growth. If heavy pruning were performed on filler trees in advance of a light crop year, the tree would tend to form an excessive amount of water sprouts and other vegetative growth which actually may result in little or no bearing for several years until vegetative growth and fruiting become better balanced.

When fillers are headed back or pruned severely, it is often desirable to ring the trunk or scaffold limbs in late May each year.[1] This practice encourages blossom-bud formation and improves the yields and quality of fruit on the fillers. The fruit on such ringed and heavily pruned trees is especially large and well colored. It also tends to keep the filler trees smaller and delays the time when they begin to crowd the permanent trees. When the permanent trees need all of the room after 18 to 20 years, actually it is not a mental hazard to remove the butchered filler trees. Experience has shown that filler trees can be successfully handled over a period of eight to ten fruiting years with successful annual trunk ringing and heavy heading-back pruning. Such a practice should not be started, however, until there is evidence that the fillers are beginning to interfere with the permanent trees and with the movement of machinery.

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[1] See discussion in Chapter VI on "Flower Bud Formation, Pollination, and Fruit Set" for method of ringing.

CROWDED PERMANENT TREES

Orchards are occasionally found where the planting distance is much too close and the side branches of the permanent trees have become interlaced. Most of the productive wood is found in the tops of such trees. The first problem is to admit more sunlight to the sides and centers of the trees. In some cases, the situation can be relieved by removing the alternate diagonal rows of trees. Trunks of the trees to be removed are marked with paint, and handled for the next six to eight years in a manner similar to that described for filler trees above, after which they are removed. Once the diagonal rows have been pruned to give more room to the selected permanent trees, the latter trees can be thinned out in the tops with necessary pruning in the center and the sides in order to bring the lower branches of the trees back into better production.

BRUSH DISPOSAL

It is important to promptly remove and burn the brush before spraying starts in spring. This practice aids in better control of insects and diseases. A homemade brush rake, as shown in Figure 61, properly attached to the front of a tractor is the most economical method of brush disposal in large orchards where the tree rows are long and the land relatively level. Brush burners can be used satisfactorily in young orchards where the heat is not likely to come close enough to the trees to cause burning, or where there is no fire hazard from a heavy cover crop. Sections of woven wire fencing (Figure 62) or sleds can be economically constructed for hauling brush to large piles outside the orchard for burning. Motor-driven brush shredders are owned and operated co-operatively by several growers in some regions. These machines are tractor-drawn over windrows of brush which they pick up, shred, and return to the row middles.[1]

REJUVENATION OF OLD OR NEGLECTED ORCHARDS

In a neglected orchard, the lower limbs become matted and dwarfed and eventually may die from lack of light. On the other hand, the top-most limbs continue growing upward until the tree is out of economical reach from the standpoint of spraying and other orchard operations. If the lower limbs have only been dwarfed or sparsely killed, it may be possible to lower the trees and bring the bearing surfaces at a more economical height. The taller top branches should be headed back to relatively strong laterals. Do not prune the tall branches back to weak side branches or open the tree excessively, causing sunscald on scaffold limbs. It is best to space such pruning operations over a period of two to four years. It is unwise under any conditions to prune a tree excessively at one time to bring about a desired shape or condition. If one is in doubt as to what to do with neglected trees, it is probably best to depend almost entirely on thinning out the branches in the tops.

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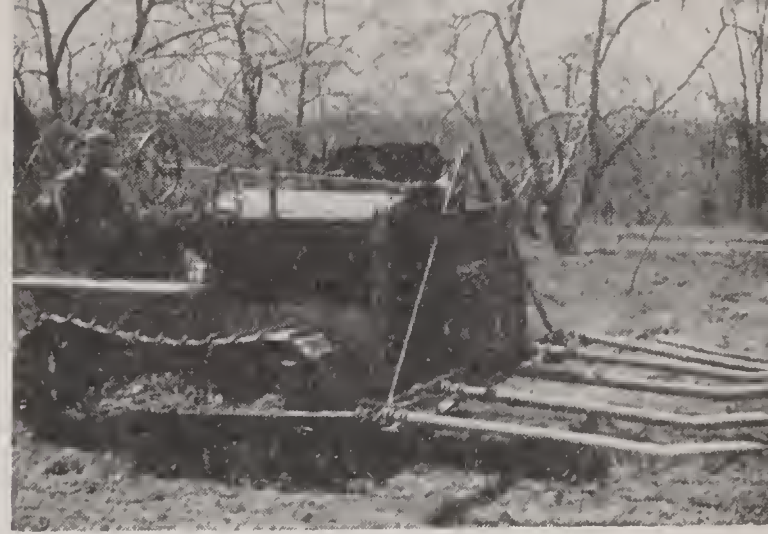
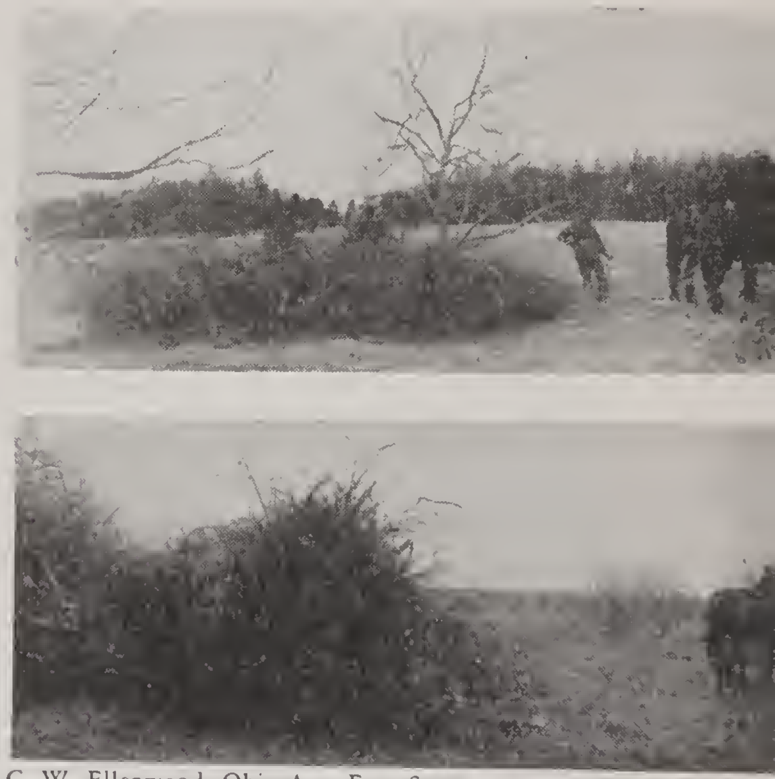
[1] For information contact Valley Foundry and Machine Works, Inc., Fresno, California.



Ohio Agr. Exp. Sta.

Figure 61. Prunings thrown in the middle of the rows just beyond the spread of the branches are quickly collected and pushed to piles with brush rake operating like a buck rake attached to the front of a tractor.

In recent years from a commercial standpoint, it does not appear advisable to leave apple trees in the orchard longer than 35 or 40 years, at which time they are on the decline in production of quality fruit. It seems best under present conditions of keen competition in production and marketing to remove old neglected trees from the orchard and replace with young trees. Under some conditions, it may be desirable, however, to perform the minimum amount of pruning in such trees in order that larger crops may be secured for the next four to six years, and in the meantime interplant with young trees. Or, if necessary, remove every other row of the old trees and replant with young trees. It has been found unwise, however, to plant a young tree precisely on the spot where an old tree grew. It is best to plant in the middles. Young trees under these conditions should be given special care in pruning and soil management. If the old trees are being grown in sod, the young trees should be either strip cultivated or heavily mulched and well fertilized to promote good growth.



C. W. Ellenwood, Ohio Agr. Exp. Sta.

Figure 62. (Top) Length of woven wire fencing, on which brush is piled, is convenient and inexpensive for hauling the brush. Fencing is nailed to a wooden cross frame at each end with a length of chain or cable attached to rear of frame. (Bottom) Cable is thrown forward over load and used to pull or roll off the brush in a pile for burning.

The greatest problem of planting young trees in old orchards is the effect of shading by the large trees. Under shade conditions, the young trees tend to make a spindly type of growth with poor development of the lower branches. If the old trees are well spaced, little difficulty will be encountered from shading. However, if they are spaced close, it would be wise to remove large branches on the old trees in order to admit more light to the young trees. Needless to say, five or more years will be gained by interplanting young trees among old trees before the latter are removed.

ADAPT THE PRUNING TO THE VARIETY

Most dormant apple trees look alike to the person who has had little experience with them. However, after considerable experience with trees of different varieties, it is possible to see many differences in growth habits which enable the workmen to identify one dormant apple variety from another. Because of these differences in growth and fruiting habits, it is necessary to emphasize a certain type of pruning on one variety and perform little or none of it on another. The following suggestions are given for a few of the more popular varieties.

Delicious. This variety is subject to weak crotches and tends to grow many limbs from the same point on a branch, forming whorls. It is highly essential that young Delicious trees be visited once a year for the first six or eight years in the orchard to correct fast-growing narrow-angled crotches and to reduce the number of limbs in a whorl to at least two or preferably one limb. Delicious develops numerous medium-size branches and the trees eventually become dense unless removal of some of these limbs is done with lopping shears and a saw. One must be careful, however, not to overprune Delicious.

Since this variety is more profitable when grown as a large fancy eating apple, it is important to get good branch spacing to admit sunlight, and that this be followed by removal of underhanging thin-wood. Delicious has a weakness in setting light crops, which this type of pruning will assist in correcting. An interrelated program of pruning, fruit thinning, and soil management should be maintained in order to obtain 15-inch terminal growths on Delicious.

Jonathan. Due to the development of numerous branches and twigs on Jonathan trees, the lower limbs may become shaded soon after the trees begin to bear. Jonathan responds better to thinning-out cuts than to heading-back cuts. It is best to remove undesired branches entirely and then distribute small cuts on the remaining branches. With good thinning-out and detail pruning, Jonathan will require little or no hand thinning of fruit in July.

McIntosh. The general growth habit of McIntosh is good and, therefore, it is easier to train when young. It is important, however, to have the limbs well spaced so that spray can enter the trees freely in order to control scab to which McIntosh is readily susceptible. Also, keep the tops low to facilitate effective spraying in these areas where a major portion of the crop is borne. Much of the fruit thinning labor in July can be by-passed by good detail pruning.

Stayman Winesap. Under good soil management, this variety develops many long leggy branches with poorly spaced scattered laterals. On young trees, some heading-back is necessary to produce laterals on terminal growths 30 inches or more in length. Stayman Winesap is an open grower and it is not necessary to make many large cuts except to avoid double leaders or weak crotches. A combination of weak crotches and wood that tends to split easily with Stayman makes it highly important to correct weak crotches early in the life of the tree. It is necessary that this variety be kept in vigorous condition by over-all annual detail pruning and a good soil management program. Due to the fact that it is an open grower, lopping shears can be used for a large portion of the pruning work.

Rome Beauty. Young Rome Beauty trees are sometimes discouraging to the pruner because most of the limbs tend to grow straight up, making a dense crowded situation. *Annual attention* to training young Rome Beauty trees is highly important. As the young trees begin to bear fruit, however, the weight of the fruit pulls the limbs out and the tree gradually assumes a spreading habit.

Rome Beauty bears much of its fruit terminally on rather long twigs at the ends of the limbs and branches. As a result of this bearing habit, the hand shears must be used freely on mature trees to remove the excess amount of twiggy growth which develops toward the outside of the tree. Much attention must be given to thin-wood pruning. It is important to start from the outer end of the branches and work toward the base, scattering the cuts more or less evenly. It is a common mistake in pruning bearing Rome Beauty trees to start at the base of a large limb and prune outward, taking off practically all of the branches for a considerable distance, leaving a “cow tail” situation with unpruned bushy twigs at the ends of the branches.

Yellow Transparent. This variety tends to become dense by producing an excess of small and medium-size branches. A portion of these branches should be removed. The remaining branches should be detail and thin-wood pruned. Relatively little topping of the outward-growing laterals is needed under these conditions. Yellow Transparent has a tendency to set heavy crops in some years and small crops in others. One should plan his pruning particularly in advance of an expected heavy crop. In addition, the trees should be hand-thinned so that the job is completed about a month after blooming. For this variety, both hand thinning of fruit and pruning are important in order to obtain good-size fruit.

Wealthy. Wealthy should not be permitted to overbear in any one year due to the fact that it may subsequently become a weak grower and a distinctly biennial cropper. Considerable detail and thin-wood pruning is necessary to promote good color and to prevent the tree from becoming thick. The cultural and pruning program should be regulated so that about 15 inches of annual terminal growth is obtained on Wealthy. Early hand thinning of the fruit, as with Yellow Transparent, is highly important.

Golden Delicious. This variety has the weakness of developing forks and narrow-angled crotches. In addition, its long leggy branches are brittle and break easily with the first heavy load of fruit. Therefore, special annual attention is important while the trees are young to get well-spaced scaffold limbs (12 inches apart) each of which is of good diameter and strong. Golden Delicious bears early (five to seven years) and training cuts are not likely to retard bearing.

It is not necessary to head-back or modify the leader at a height of six or eight feet; the leader can be pulled to a side by removing the small branches on the side toward the prevailing wind. Fruit on the other side of the leader, with the help of the wind, will pull this branch to the side. In mature trees, thin-wood pruning is highly important to attain large size of fruit. Thin-wood pruning is essential on mature trees to get large-size fruits.

Northern Spy. The young tree is dense and very upright; it begins to bear late at about 12 years. Therefore, the young trees must be pruned lightly in order that the fruiting will not be delayed longer than 12 years. Forked and narrow-angled crotches are a weakness. If the side limbs are tied down with staples and string as described previously, this tends to spread the tree and also to bring it into earlier bearing. Detail and thin-wood pruning from a ladder is necessary on mature trees to eliminate matted conditions, to give better scab control, and to prevent limb rub.

Grimes Golden. Grimes Golden is different from most varieties of apples in that it bears its fruit relatively deep in the tree. Thus, it is highly important to get good branch spacing and to keep the top open to admit light to the bearing spurs toward the inside of the tree. The response in size and quality of fruit to this practice is particularly good with Grimes Golden. It is a serious mistake to "cow-tail" prune the large branches of Grimes Golden because such a practice removes the main fruiting wood of this variety.

Baldwin. Annual or biennial attention to pruning is necessary with Baldwin to prevent it from developing a biennial bearing habit. This variety has a strong tendency to overbear in some seasons and should receive somewhat more pruning the winter preceding the big-crop year. Due to the fact that Baldwin is a strong dense grower, it needs relatively more thin-wood and detail pruning, using both lopping and hand shears to keep the tree open. This practice results in improved size, color and quality of fruit.

Review Questions

1. What factors influence the kind and amount of pruning on an apple tree?
2. Why is the dormant season preferred for pruning apple trees?
3. Why is pruning in the early dormant season hazardous in some sections of the country?
4. Describe the proper procedure for (1) removing a branch ½-inch thick at the base; (2) the removal of a 3-inch branch.
5. Explain why stubs should not be left while pruning.
6. What type of pruning cuts are used to keep a mature apple tree within height and width bounds; explain how the cut is made.

7. Why are narrow-angled crotches weak?
8. Pruning is a dwarfing process! Why?
9. Describe the arrangement of limbs on an apple tree trained to the modified leader system.
10. Explain how (1) a 1-year and (2) a 2-year nursery apple tree are pruned at planting time.
11. What is meant by the "deshooting system" of training newly planted apple trees?
12. How can a double leader be corrected?
13. Why should the small twigs be left on the lower branches of young trees?
14. Describe a weak and vigorous apple spur; why do some apple spurs grow in a zigzag fashion?
15. How can you recognize a flower bud and a leaf bud on dormant apple wood?
16. List the benefits of pruning mature bearing apple trees.
17. Why should the tops of mature apple trees be kept low, or, about 20 feet from the ground?
18. How does the pruning of a filler tree differ from the pruning of a permanent tree?
19. How does the pruning of a bearing Delicious tree differ from the pruning of a bearing McIntosh?

Suggested Collateral Readings

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CHAPTER V

Soil Management for Apples

No single cultural program can be recommended for all orchards. A program that is satisfactory for one orchard under one set of climatic and soil conditions may be undesirable for another under a different set of conditions. Good tree performance often may be obtained under any one of several different systems of management. The cultural program selected, however, must be interrelated with the pruning, fertilization, fruit thinning, and the spraying programs to obtain good shoot growth, moderate over-all tree vigor, and high production of quality fruit. It is a general observation that fruit trees respond more or less directly to the soil type in growth and yield; the more favorable the soil, the less important is the particular cultural program to be followed.

Many orchards have been planted on rolling or relatively steep land in order to secure good air drainage and freedom from frost damage. These orchards are subject to soil erosion, and special care must be exercised in the cultural program to minimize erosion as much as possible. If the slope of the land is less than 10 per cent, contour planting with or without terracing is highly effective in conserving both soil and moisture. However, if the slope is greater than about 10 per cent, the orchardist is almost forced to keep his land in a continuous sod.

It is important to choose a soil management program which will meet the following objectives:

1. Provide a *favorable moisture supply* to the trees throughout the growing season.

2. Minimize or *prevent soil erosion.*

3. *Increase,* or at least *maintain,* the *organic matter* to compensate for loss by erosion, decomposition, or other means.

4. Supply necessary nutrients.
5. Loosen the soil for good aeration and prevent excessive compacting by heavy machinery.

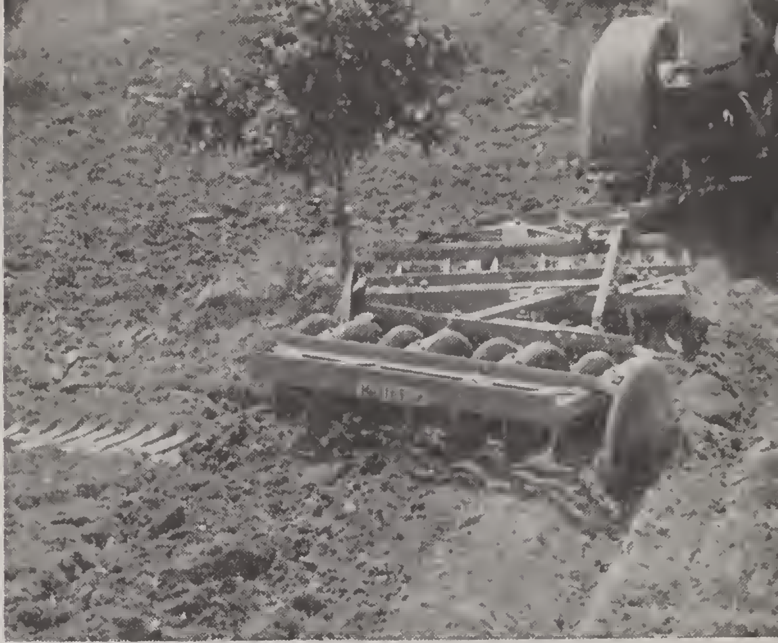
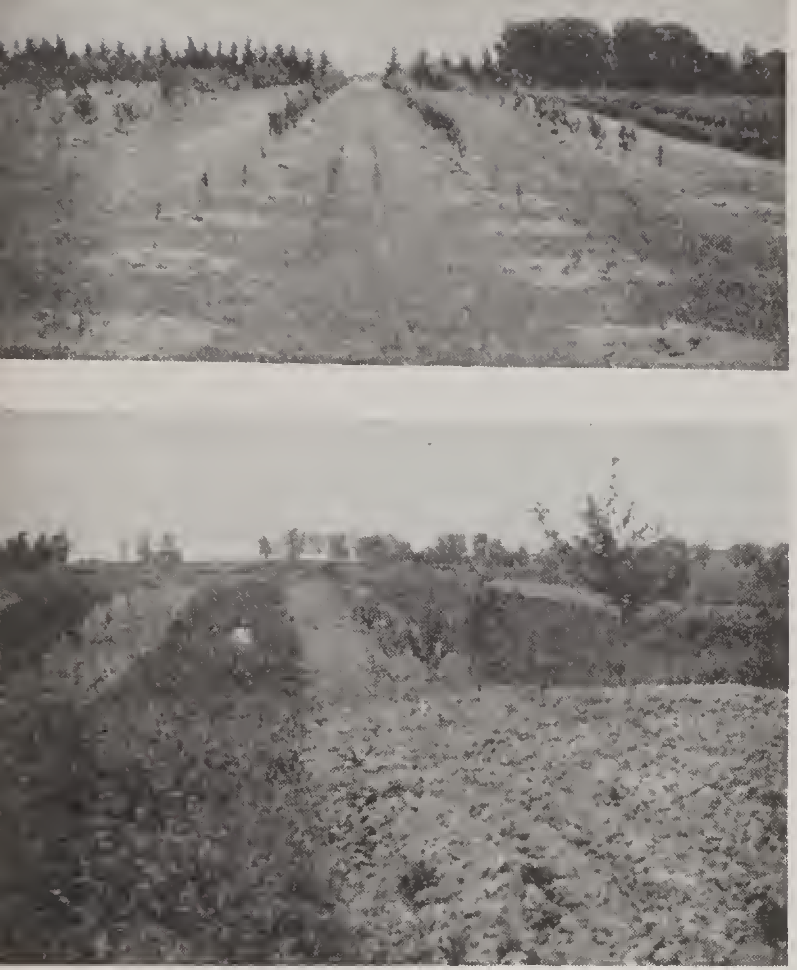

John Deere Co., Moline, Ill.

Figure 63. A narrow double disk is convenient for cultivating next to young trees for a distance of five to six feet on either side.

It is generally agreed that the young apple orchard requires a different type of soil management than the mature bearing orchard. This is because young trees are shallow-rooted and are more likely to suffer from limited supplies of nutrients and water. The older trees, on the other hand, are less subject to competition with sod for water and nutrients because their root systems permeate the soil to a greater width and depth; also, they have greater food reserves in the bark and wood tissues to tide them over periods of stress.

Soil management for young apple trees. It is desirable to secure from 15 to 30 inches of terminal growth each year on young apple trees, the longer lengths being required for the younger trees. In order to attain this vigor, some system of management involving *clean cultivation* is usually necessary, beginning shortly after growth starts in spring (Figure 63). The soil is disked only enough to keep down excessive weed growth until either the first of June when an intercrop or a summer cover crop is sown, or until mid- or late summer when a winter cover crop is planted. Both a summer and winter cover crop are often used in an orchard to increase the organic matter of the soil when disked under. In case of sloping land, it is imperative that the cultivation always be performed on the contour or across the slope, *not* up and down the slope. If the slope of the land is such that erosion is likely to occur when the entire area is cultivated, it might be well to perform what is known as *strip cultivation* where the soil is shallow-disked for a width of five to six feet on either side of the trees and the middles are left in sod to check erosion. If the strips are in alfalfa, timothy, or a similar hay crop, the hay can be harvested for a few years and used for mulch on neighboring bearing trees or fed to livestock without deleterious effects on the apple trees. Sod strips are also convenient for operation of heavy equipment such as spray machines during soggy weather. The sod strips are gradually narrowed until the trees are about eight to ten years of age, after which a new program is initiated as described later under "Soil Management for Bearing Apple Trees."

If the land is more or less level and can be entirely cultivated, a satisfactory soil management system is to grow cultivated crops between the tree rows and derive cash income from the land while the trees are coming into



(Top) Ohio Agr. Exp. Sta., (Bottom) J. R. Magness, U.S.D.A.

Figure 64. (Top) This management system is well adapted to steep sections of the orchard. Grass is cut one to three times a year, raked toward the trees with a side-delivery rake, and mulched about the trees by hand. If sufficient nitrogen fertilizer is applied with this system, growth is almost as good as with cultivation, and with less expense. (Bottom) Strip cultivation of young apple orchards with the middles left in sod is often used on rolling land to help control soil erosion.

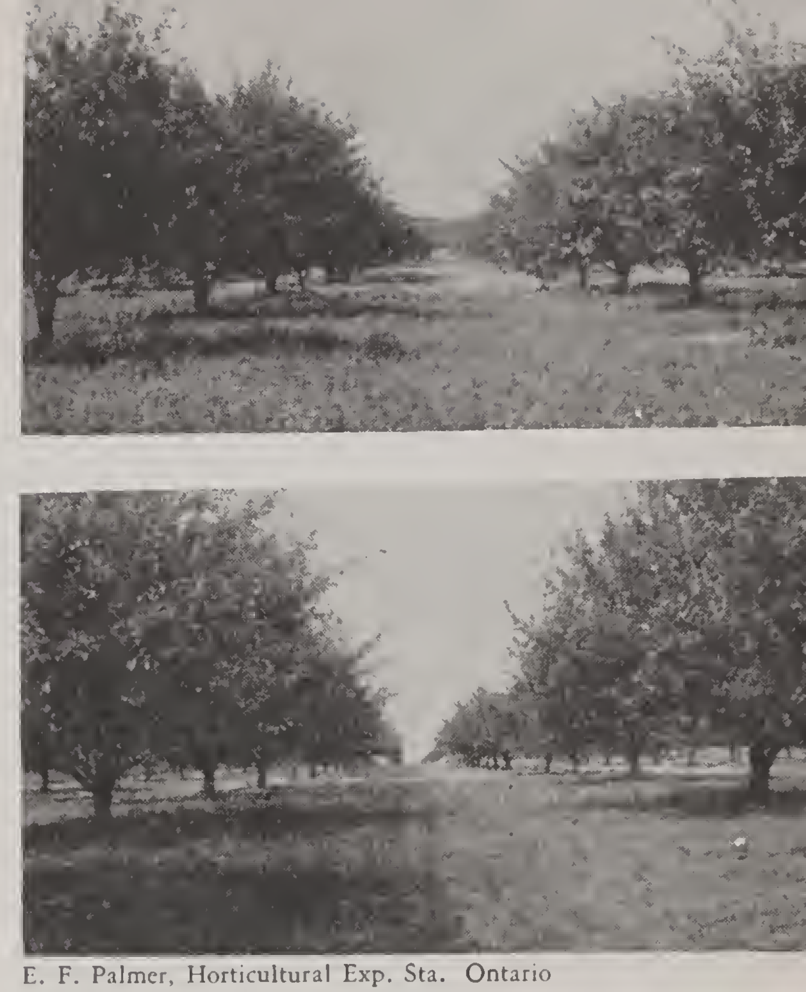
bearing. Intercrops which appear to be well suited to this purpose are tomatoes, cabbage, beans, strawberries, and early potatoes. The use of grain crops is questionable because they require considerable nitrates and moisture and may compete with the trees, especially when planted close to them. Crops such as tomatoes and beans are usually more satisfactory than early potatoes in the middle Atlantic States because they are planted later and do not compete for moisture and nitrates with the trees at a time when the trees need them most. The intercrops should not be closer to the trees than five feet. With this system of management, the fruit trees derive benefits from the cultivation and fertilization practices of the intercrop. It is important that the intercrops be harvested in time to sow a winter cover crop such as rye or wheat to protect the soil during the dormant period.

On land steeper than a 10 per cent slope (drop of 10 feet in 100 feet; too steep for practical terrace management), it is dangerous to perform any type of cultivation, except hoeing for a distance of three to four feet about the base of each tree, which requires considerable hand labor. One of the better soil management systems for hillside trees, according to recent experiments, is to place the land in permanent sod, cut the grass two or three times a year and place it around the base of the tree as a mulch (Figure 64). The mulch should be maintained at least six inches deep and, if necessary, additional mulch can be cut and brought from neighboring fields. Trees under this or any sod management program will require a plentiful supply of nitrogen, especially shortly after the first mulch has been applied; otherwise, the bacteria which decompose the mulch may "tie up" nitrogen and cause a deficiency of this element in the tree. In order to increase the moisture supply to young trees on slopes, some growers have plowed out a short four- to six-foot strip about two feet above the tree which serves to catch and hold additional rain water during periods of infrequent rains.

Clean cultivation of young trees with cover crops or intercrops should be discontinued when the trees are about eight to ten years of age. By this time, the tree limbs will begin to interfere with cultivation and reduce the sunlight reaching the intercrop which itself has been narrowed to fewer rows.

Soil management for bearing apple trees. Horticulturists in Canada and many of the western and eastern states are generally agreed that a program of continuous cultivation with cover crops throughout the life of the orchard is detrimental both to the soil and to the trees. In many of the leading apple states, a cultural program often recommended for bearing trees and now rapidly gaining favor is *sod mulch* where the grass or legume-grass mixture is cut and placed beneath the trees, along with *additional mulch* obtained elsewhere, if needed (Figures 65 and 66).

There are several advantages of the mulching system for mature trees:



E. F. Palmer, Horticultural Exp. Sta. Ontario

Figure 65. (Top) A permanent alfalfa sod with or without mulch is sometimes used in bearing apple orchards, especially in Western irrigated orchards or where a plentiful water supply is available. Additional water is usually needed to compensate for competition between the trees and the deep-rooted alfalfa. (Bottom) Grass sod mulch is a common cultural program in apple orchards. The grass is cut twice a season, mulched under the trees, and if necessary supplemented with additional mulch such as straw or old hay obtained elsewhere.

1. Soil moisture fluctuations beneath the trees are less, particularly during dry periods, due to reduced evaporation from the soil surface and the elimination of competition by weeds and grass growing beneath the trees.
2. The soil becomes more loose, friable, and better aerated beneath the mulch.
3. Available potassium and certain other necessary elements including phosphorus, magnesium, calcium, and boron are found to be higher in the soil beneath mulched trees.
4. There is less fluctuation in soil temperature beneath the mulch, the soil being as much as 15° cooler in summer and 5° warmer in winter as compared with tilled soil.
5. The soil organic matter in the upper two to four inches under mulch is about 1 per cent higher than under sod and 2 to 3 per cent higher than under cultivation.
6. The mulch acts as a cushion for drop apples which are less damaged and can be sold at better prices.

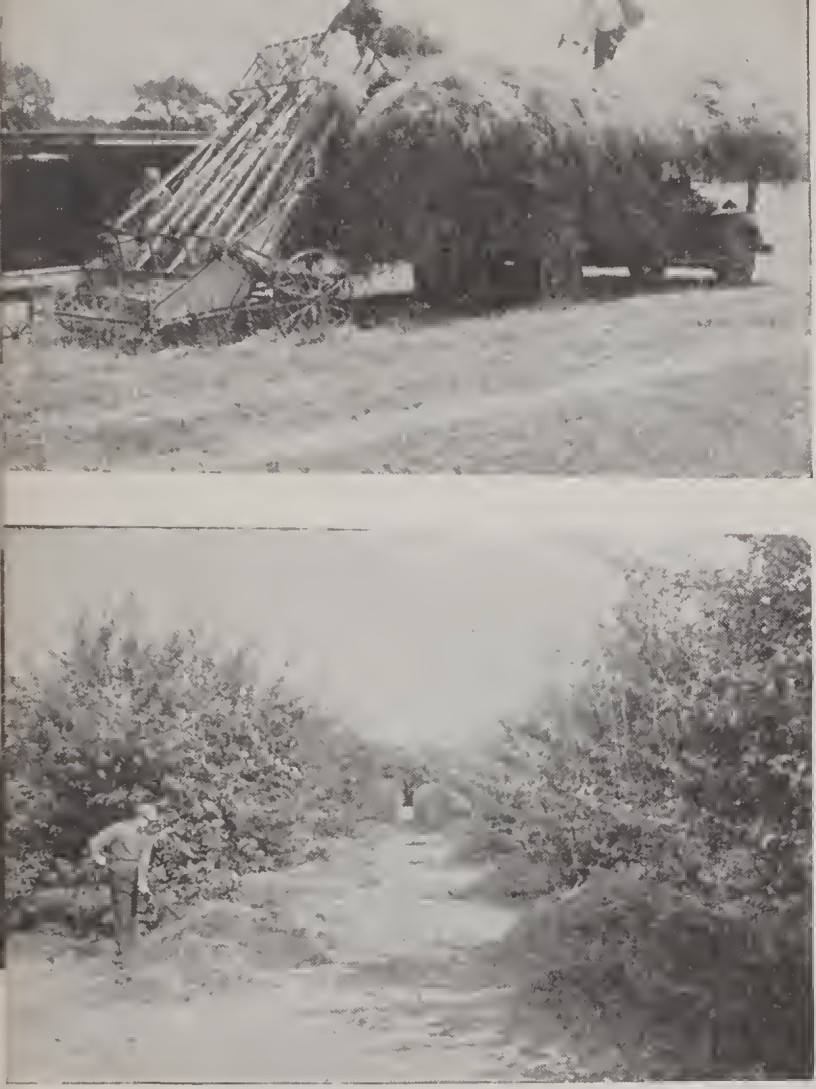
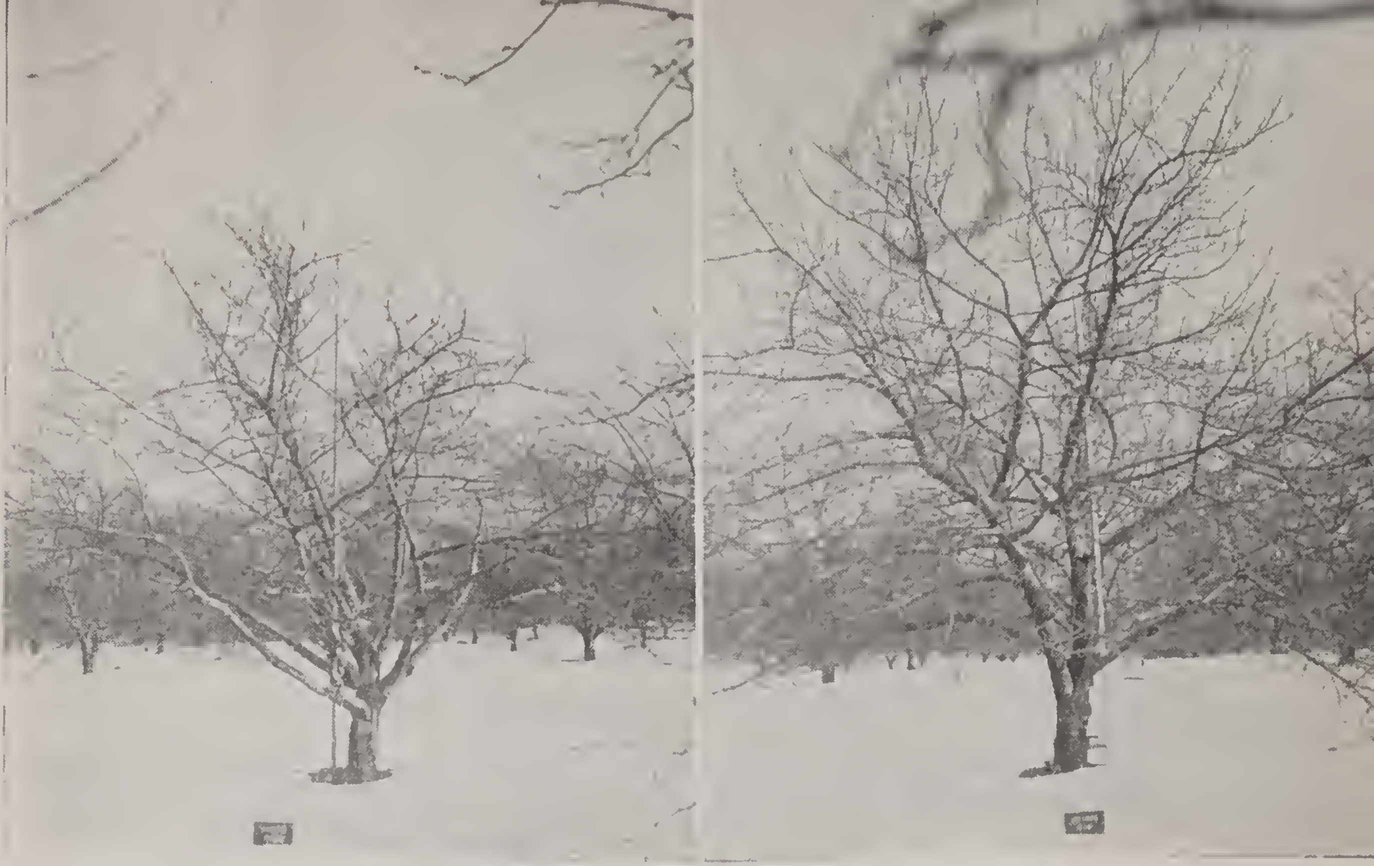


Figure 66. This commercial apple grower cuts, loads, and hauls additional mulch from his neighbor's field. (Top) Hay is purchased by the acre, uncut. Mulch production often can be doubled and tripled by an application of commercial fertilizer, particularly nitrogen. (Bottom) Mulch collected as shown in the top picture is unloaded in June and July adjacent to trees bearing good crops and spread evenly beneath the branches to within two feet of the trunk.

7. The growth and yields of apple trees under this system have been shown to be almost as good and in some cases better than those under clean cultivation with cover crops, especially when the life period of the orchard is considered. At the Michigan Experiment Station, the clean cultivation with cover-crop system of managing apple trees was satisfactory for about the first ten years, but by the time the trees were 20-22 years of age, growth in circumference of the trees, on the average, was less per tree (Figure 67). Also, the yield and quality of the fruit were significantly less on cultivated as compared with mulched trees. Continuous cultivation in an orchard depletes the organic matter and destroys the loose structure, causing the soil to puddle, pack, crack, and be less absorptive and retentive of moisture.

8. The color and quality of fruit is better under a sod or sod mulch system of management, as compared with cultivation. This is because continued cultivation tends to release nitrogen in the soil which, in turn, is available to the tree throughout the growing and ripening season. This nitrogen is largely in addition to that applied as a chemical fertilizer in the spring. Relatively high nitrogen during the ripening period depresses coloring of the apple and keeps the tree growing too late in the season, resulting in greater susceptibility to winter injury. In case of the sod management system with nitrogen fertilization and additional mulch, the tree and grass normally have utilized most of the excess nitrogen by the middle of the summer. As the fruit begins to ripen, the carbohydrates manufactured by the leaves tend to accumulate in the fruit rather than being diverted to additional shoot growth. With the high carbohydrate condition in the apple, coloring is better, provided the temperatures are cool and good light reaches the fruit during a few hours of the day.

9. A liberal supply of hay mulch furnishes adequate nitrogen and other elements after the first two or three years of use, and no commercial fertiliza-



Walter Toenjes, Michigan Exp. Sta.

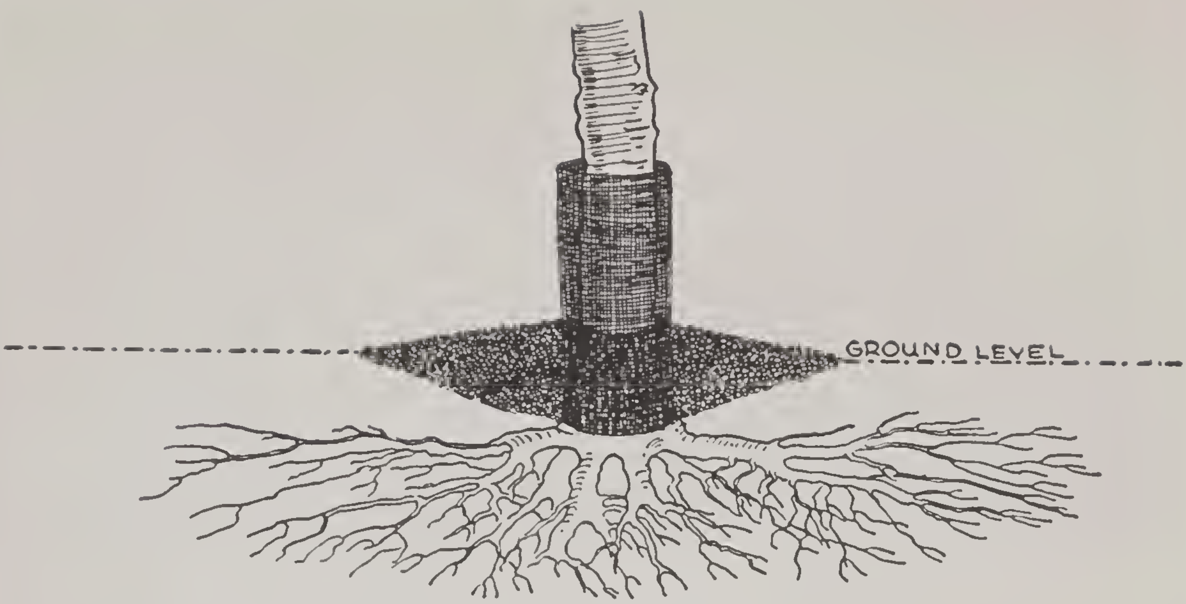
Figure 67. Grimes Golden trees in neighboring plots receiving different soil management programs. (Left) Typical tree under clean cultivation with cover crops for 22 years; trunk circumference was 31 11/16 inches. (Right) Tree under sod-mulch plus additional mulch for 21 years (cultivated with cover crop the first year); trunk diameter was 34 13/16 inches. Compare heights of the two trees with 20-foot pole in center of trees. Experiment demonstrated that clean cultivation with cover crops over a 22-year period was detrimental to soil structure and to size and yield of trees.

tion is required thereafter, provided the layer of mulch is maintained year after year (based on experimental data in Massachusetts).

The sod system with mulching has some limitations:

1. The mulch and dry grass become a fire hazard during dry periods.
2. The mulch may harbor insects, diseases, and rodents.
3. The cost of additional mulch material may make it prohibitive.

The *fire hazard* can be minimized by strip plowing across the slope, making the strips about six feet wide in every second to fourth middle. This is particularly important near railroads where sparks from the engine may start fires. Also, during periods of drought, the spray machine should be kept in readiness with a quickly available water supply for the purpose of fighting a fire. To avoid damage by *mice,* it is important to keep the mulch one and one-half to two feet away from the base of the tree, especially during winter. An added measure is to use cinders and a sheet of one-fourth-inch mesh galvanized cloth (14 to 20 inches high) around the base of the tree, as shown in Figure 68. It is also advisable to execute a regular poisoning program for the mice in late October each year. The poison bait is placed in tilted tin cans which are laid perpendicular to the active runways under the trees and



W. J. Hamilton, Jr., Cornell University

Figure 68. A one-quarter-inch mesh galvanized cloth around the trunk protects against mouse and rabbit injury. If the soil is well drained, additional use of soft coal cinders to a depth of six inches serves to irritate the feet and stomachs of the mice, repelling them.

along the fence rows.[1] They should be inaccessible to birds and other animals. A poisoning program for mice is good precaution regardless of whether the trees are cultivated or in sod and mulch. The *field,* or *meadow mouse* (*Microtus pennsylvanicus,* Figure 69), works on the soil surface or a few inches below the surface. Most of his damage consists of bark injury to the tree near the soil surface. In some regions, such as southern New York, the Virginias, and regions of similar climates, the *pine mouse* (*Pitymys pinetorum scalopsoides*) is a serious pest, causing bark damage on the roots, as shown in Figure 70. Damage by this species of mouse is serious because it is difficult to detect the damage before it is too late to save the tree. It is also inconvenient and hard to correct the situation by bridge-grafting, as can be done for damage by the meadow mouse. (For methods on bridge-grafting, see Chapter VIII.)

Source of mulch. It is impossible to grow sufficient mulch between mature apple trees to adequately maintain the mulch at a depth of six to eight inches under the trees. Thus, it becomes necessary to collect or buy additional mulch outside the orchard. This may consist of wheat or oat straw from old stacks, spoiled legume hay, corn cobs, sawdust, leached cinders, or similar materials. Sawdust obtained from some trees may be acid, and lime should be added to the mulch to correct the acidity. A large commercial grower in

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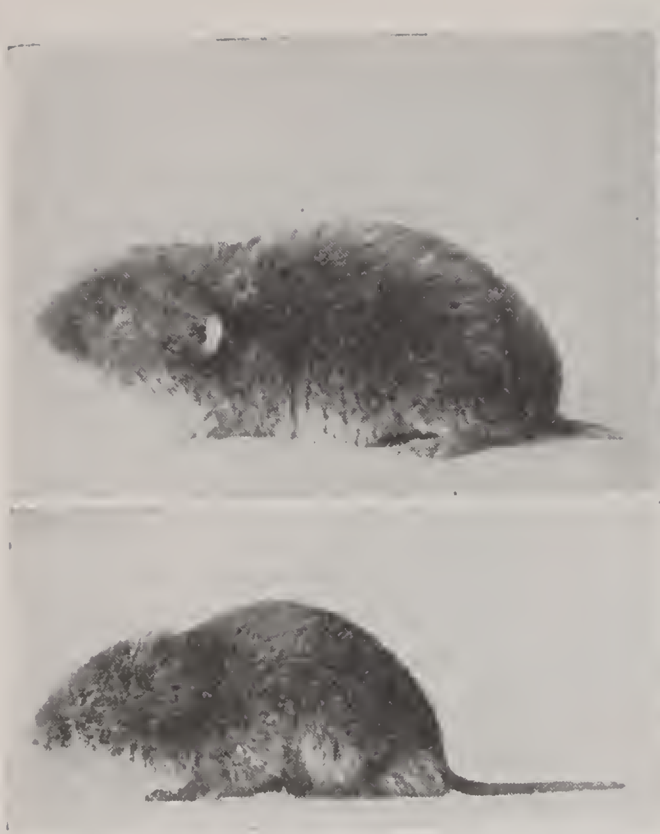
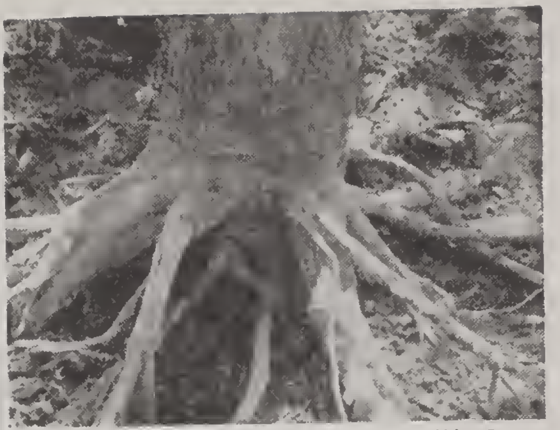
[1] One-half inch cubes of fresh apple and carrot, mixed half and half, and dusted with powdered arsenic make excellent bait during periods when there are no windfall fruits on the ground. Otherwise, strychnine oats serve well, obtained through the county agricultural agent. Recently, a zinc phosphide rodenticide has been perfected by the Fish and Wildlife Service, U. S. Department of Interior, but due to the poisonous nature of this bait, it has been necessary for the grower to work through the county agricultural agent. Frequent contact should be made with this and other officials to keep up-to-date with the newer rodenticides under experimentation.



W. F. Kubichek, Fish and Wildlife Service, U.S. Dept. of Int.

Figure 69. Two species of mice injurious to fruit trees. (Top) The pine mouse has a small body, short tail, Roman nose, sunken eyes, and brownish fur. He burrows underground and causes damage to roots. (Bottom) The meadow mouse has a large body, long tail, prominent eyes, and dark-grayish fur. He makes surface marks.



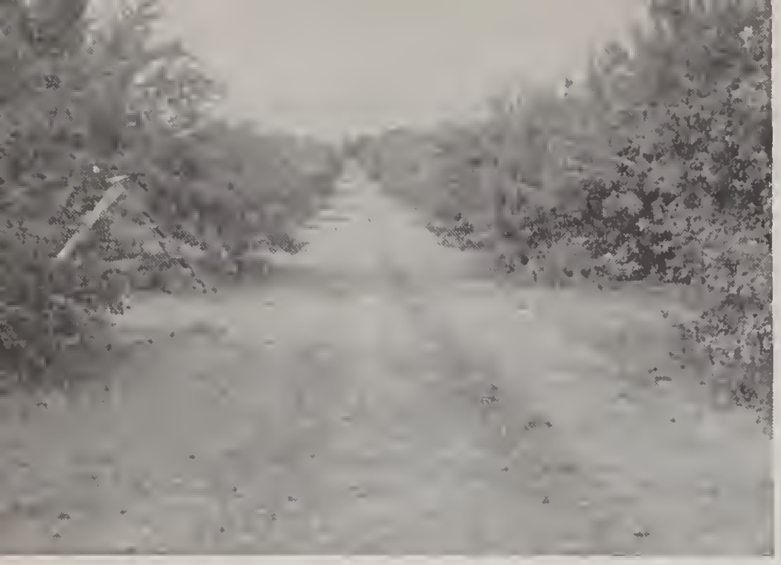
W. F. Kubichek, Fish and Wildlife Service, U.S. Dept. of Int.

Figure 70. Injury to apple tree roots by the pine mouse (*Pitymys pinetarum scalopsoides*) is difficult to detect before it is too late to save the tree. A regular poisoning program is effective in preventing this damage in areas where these mice are known to exist.

Ohio has made it a regular practice of buying mulch material from his neighbors with the understanding that he (the grower) will cut the hay, load it, and carry it to his trees, as shown in Figures 66 and 71.

Whether the mulch is obtained between the trees or from fields outside the orchard, it has been shown by the Ohio Agricultural Experiment Station that nitrogen fertilization will often result in greatly increased yields of mulch per acre. For example, the use of 400 pounds of cyanamid per acre on a rather infertile soil more than tripled the production of dry grasses from 1573 to 5143 pounds per acre. Nitrogen is the fertilizer that ordinarily gives best response with grasses. When timothy is top-dressed with about 300 pounds of sulfate of ammonia or cyanamid, it should yield between one and one-half to two tons of mulch per acre, sometimes more depending upon rainfall. A mixture of Sudan grass and soybeans in some regions may produce as much as two and one-half tons per acre. German or Siberian millet sown about June 1 and cut September 1, followed by rye which is cut in the spring should give about four to five tons of fresh material per acre per year on reasonably fertile land with additional fertilizers. It requires about an acre of land to produce sufficient mulch for an acre of mature trees. The grasses and grains make better mulch material than legumes because they decompose more slowly and ordinarily do not need renewing more than once every other year.

Cost of mulch. The cost of mulch varies considerably and the use of additional mulch in an orchard may be governed entirely by its expense. A



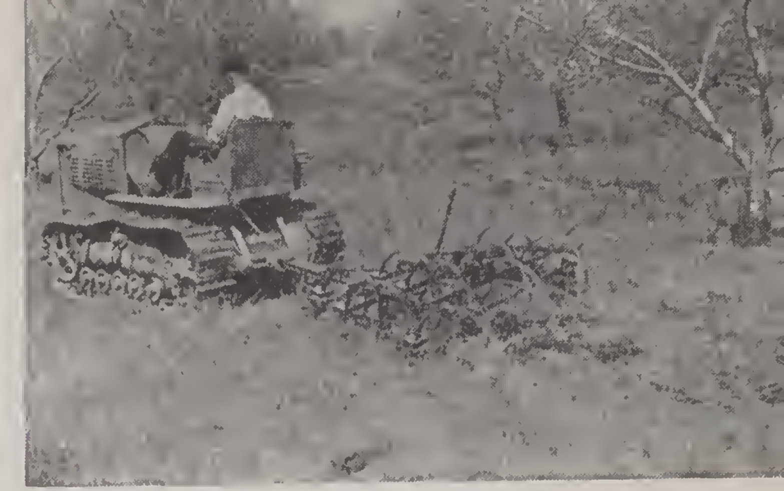
Ohio State University Agr. Ext. Serv.

Figure 71. In this relatively level orchard near Lake Erie, soil between the trees is cultivated with a disk or a "weed hog" until midsummer, after which volunteer weeds and grass or a special cover crop takes over. The areas beneath the spread of branches are well mulched at least every other year. Note excellent tree vigor.

mature tree requires about 200 to 300 pounds of straw, or two to three bales for the first mulching, after which 100 pounds per year or 200 pounds every other year should be sufficient. Some horticulturists recommend the application of 100 pounds every year rather than 200 pounds in alternate years, because the latter application leaves a thick mulch which during relatively dry periods may absorb the entire limited rainfall, preventing it from reaching the tree roots. An average value for mulch might be placed at $15.00 per ton. When there are 30 trees per acre, this would be $22.00 to $30.00 per acre per year, with labor for applying the mulch not included. Sometimes straw can be purchased cheaper than this, but the approximate cost of mulching an orchard will need to be calculated by the grower under local conditions and prices.

With a mature orchard in sod alone or sod plus additional mulch, it is good practice to loosen the sod about two weeks before bloom with a "weed hog" or "ground ripper," as shown in Figure 72. Some growers do this once every spring, others once every five to eight years. If done at several-year intervals, it helps to correct a more or less "sod bound" condition, stimulates growth of the sod, and loosens the soil for better absorption and penetration of rainfall. This "set-back" to the sod also reduces the water and nitrogen requirements by the grass at a time when they are most needed by the trees. The grass recovers about the middle of the summer and by winter, it is well established to prevent erosion during the dormant period. This system of management is sometimes called "short-sod rotation" when practiced at intervals of five to eight years. Some growers go so far as to prepare a special seedbed for another permanent sod to be planted about the first of August. A seed mixture which has been used successfully for permanent sods in mature orchards is: four pounds each of alfalfa, red clover, bluegrass and timothy, and two pounds of alsike clover per acre. Another combination often used where more mulch is required is six to eight pounds each of timothy and red clover, two pounds of alsike, and four pounds of bluegrass. Alfalfa alone is a commonly used permanent sod in the West. Good germination is secured if the seed is sown on a well-prepared seedbed following a shower.

A word of caution should be given against mechanical injury to young and mature trees by orchard implements. Broken branches, and patches of bark knocked off the trunk, are serious injuries to a tree. Tractors with smooth fenders and few, if any, projecting parts are preferred. Burlap, rubber inner tubes, or similar materials can be used for covering projecting and sharp metal. If a team is used, hardnesses without projecting hames are desirable. Whiffletrees should be short as possible and the ends wrapped with burlap. The most valuable preventative of injury to trees is a *skillful* and *careful* driver. A moment's carelessness may cause an injury that will take years to heal or, in fact, threaten the life of the tree.



J. K. Shaw, Massachusetts State College

Figure 72. This type of harraw, known as a "ground ripper," is useful in checking growth of grass in sod orchards during the spring and early summer. This practice reduces competition between the grass and trees during a critical growth period and loosens a compacted soil resulting from frequent heavy machine travel.

Orchard cover crops. The use of cover crops between the tree rows is recommended as a part of any program where cultivation is practiced. A cover crop may be either grown for a few months during the summer season, then disked down, or it may be grown in late summer and fall, and disked under the following spring. Cover crops have the following advantages:

1. They add organic matter and help maintain the humus content of the soil.
2. Heavy soils become easier to work and light soils are improved in physical condition and in their ability to retain moisture.
3. Nitrogen is added to the soil if the cover crop is a legume.
4. When a cover crop is competing with the trees for nitrogen and water in late summer and autumn, the wood of young vigorously growing trees is better matured and less susceptible to winter injury.
5. Cover crops protect the soil against erosion.
6. They moderate the soil temperature, retain snow better, and reduce the likelihood of winter injury to the roots.
7. Cover crops absorb mineral nutrients, preventing them from being leached away over winter.
8. After spring disking, the organic matter of the cover crop decays and assists in making available the mineral nutrients tied up in the soil.
9. Cover crops such as rye, which have a high water requirement are valuable in absorbing excess water in orchards which tend to be too wet in spring.

There are two main types of cover crops—*legumes and nonlegumes.* The legumes, through the action of bacteria in root nodules, have the ability

TABLE 8

The Amount, Relative Cost, and Time of Seeding for Orchard Cover Crops

Cover Crop	Time of Seeding[2]	Seed per Acre	Relative Cost of Seeds[3]	Nitrogen Added Before Disking in
Legumes[1]				
Alfalfa[4]	Early Spring or Aug. 1	20 Lbs.	$ 3.86	No
Alsike Clover	July	6 Lbs.	11.34	No
Canada Peas	June	1½ Bu.	11.70	...
Cowpeas	June 1–15	1½ to 2 Bu.	15.60	No
Crimson Clover	July	16 Lbs.	5.44	No
Lespedeza	June 1	20 to 25 Lbs.	5.00	No
Red Clover	July	12 Lbs.	8.45	No
Soybeans (drills)	June 1–15	½ Bu.	2.20	No
Sweet Clover[4]	Early Spring or Aug. 1	15 Lbs.	3.45	No
Winter Vetch[4]	After August 15	1 Bu.	15.90	No
Nonlegumes				
Barley	August 15	1½ Bu.	3.05	Yes
Bluegrass	June 1	30 Lbs.	19.25	...
Buckwheat	June or July	1 Bu.	3.60	No
Cowhorn Turnips	June	2 Lbs.	2.50	Yes
Dwarf Essex Rape.....	June	2 Lbs.	0.50	...
Millet	June 1	25 to 40 Lbs.	3.75	Yes
Oats	August 15	1½ Bu.	4.20	Yes
Rye	September 1–15	1½ Bu.	3.10	Yes
Rye Grass	September 1–15	12 to 15 Lbs.	1.90	Yes
Sudan Grass	June or July	25 to 30 Lbs.	6.00	Yes
Timothy	June 1	20 Lbs.	2.36	Yes
Weeds	....	....	....	Yes

[1] The seed should be inoculated before planting if the desired legume has not been grown recently and successfully on the site. The most convenient, economical, and effective means is to purchase inoculant at the seed houses and follow directions on the bottle. Legumes generally grow better in soils near the neutral point, or slightly acid. It requires between one and two tons of agricultural limestone per acre to raise the pH one point, as, for example, from 5.0 to 6.0.

[2] Dates suggested for North Central and Northwestern states. Contact local county agent for dates for other areas.

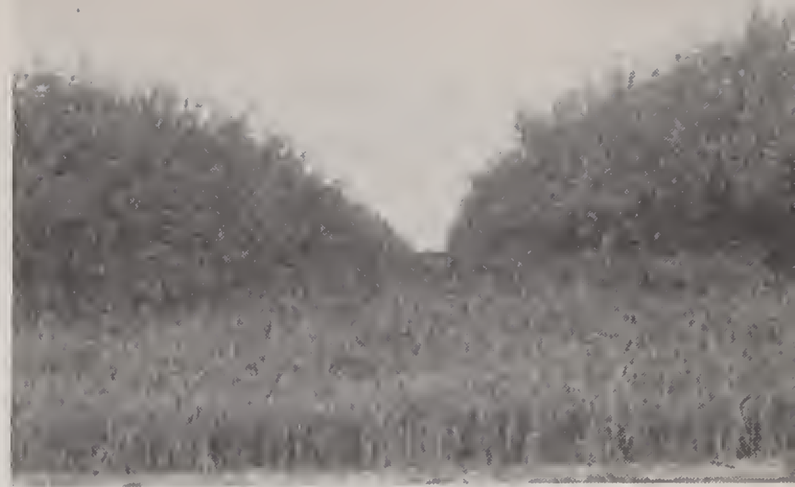
[3] Varies with season and locality. Prices obtained in 1948, New Jersey.

[4] Because initial growth is slow, it is best to sow also with a nurse crop such as oats or buckwheat.

to store nitrogen. Legumes which have been disked in, therefore, decompose rapidly, releasing the nitrogen which in turn may be utilized by the trees. The nonlegumes such as the grasses are relatively low in nitrogen and, thus, decompose slowly. It may be necessary to apply nitrogen fertilizer in order to speed up their decomposition, and avoid a depressing effect on tree growth.

The best cover crop to use will vary with the soil, the site, and the geographical location. The most satisfactory cover crop for a given region is the one which grows well and produces considerable organic matter relatively high in nitrogen.

Summer cover crops. Summer cover crops are usually sown about the first of June after a good seedbed has been prepared by thorough disking and dragging. A complete fertilizer of 250 to 300 pounds of a 2–12–6 composition is often helpful in getting both summer and winter crops off to a good start. Better germination is obtained if the seed is sown or drilled shortly after a shower.



E. F. Palmer, Horticultural Exp. Sta., Ontario

Figure 73. A nonlegume crop of millet was sown in this young orchard in early summer, following a short cultivation period ond the opplicotion of 125–250 pounds per acre of 2–12–6. The millet will be disked down in late summer ond the orchard sown to rye overwinter, or the millet can be mowed shortly before horvest ond let lie overwinter to be disked in the following spring.

Soybeans (*Soja max*). Soybeans make an excellent summer cover crop for orchards under 10 years of age. They are more popular in the Midwest and South than in the extreme northern regions and Canada. Soybeans can be grown on a somewhat more acid soil than the clovers, but lime should be added if the pH is below 5.5. They respond well to fertilization in soils with medium to high organic matter. Directions for seeding this and other cover crops are given in Table 8.

Cowpeas (*Vigna siness*). Cowpeas are handled similarly to soybeans and will grow on somewhat poorer soils. Cowpeas are grown mainly in the southeastern quarter of the United States.

Sudan Grass (Sorghum vulgare sudanensie). Sudan grass is a valuable cover crop where water is not likely to be limiting and where considerable bulk is desired to improve soil organic matter and aeration. It is a rapid grower, germinating well in hot weather and reaching four to six feet in height; hence, it may be valuable to use in cases where soybeans have failed to grow. It is necessary to apply 200–300 pounds of nitrogen fertilizer per acre to get good growth and to reduce competition for this element with the trees. In northern states and Canada, Sudan grass may not yield as much organic matter as Crown, Empire, and Japanese millets.

Millet (Setara italica, Panicum miliaceum, Echinochloa frumentacea, and others). Millet is a nonlegume which can be used for a summer or winter cover crop in young orchards where shading is not a factor (Figure 73). Its natural habitat includes regions north of Alabama and Texas, with heaviest use from Missouri eastward to Maine. In areas where droughts are likely to occur, however, it competes with the trees for water and under such conditions may be of questionable value. In young orchards, it should be kept at a distance of about five feet from the trees. It grows under a wide range of soil conditions and is not exacting in moisture requirements.

Siberian millet is valuable in orchards which are generally too wet, because it will utilize much of the excess moisture. Crown, Hog, and Red Turghai are better varieties where conditions may be dry, due to the fact that they are shallow-rooted and compete less for water.

Buckwheat. This crop is sensitive to frosts but thrives best in a cool moist climate in the northern states or near the Great Lakes. It succeeds well in sandy loam soils, but also will thrive on rather poor heavy soils, improving them for subsequent legume crops. The seed is inexpensive. When sown early, seed will mature in about two months, after which a light disking will thresh out enough seed for another crop over winter. The following spring, the orchard is cultivated for a few weeks, after which a good stand of volunteer buckwheat can be obtained during late summer and autumn. This practice can be continued for about three years from the original seeding. Buckwheat straw decomposes easily and creates little nitrogen drain.

Lespedeza (L. striata). Korean lespedeza is an annual, but it is used mainly as a permanent cover to conserve the soil. It is mostly used in the South where it will grow on the poorer types of soil. It is not a bulky grower. Seed should be sown early in the spring so that it will reseed itself for the following year. On some occasions weeds may grow taller than the lespedeza, and it is necessary to mow them in midsummer to reduce competition.

Winter cover crops. Winter cover crops are usually sown between the middle of August and the middle of September and disked down the following spring.

Rye. Rye is widely used as a cover crop because it makes good growth on relatively poor and acid soils, withstands winter freezes, and is effective in preventing soil erosion during winter. With rye, however, it is highly important that it be disked into the soil when it is about knee high. Otherwise, it competes heavily with the trees for moisture and nitrogen at the most critical growth period of the tree. The fact that rye grows so fast in spring is its biggest disadvantage because on too many occasions the land is too wet to disk, and the rye may noticeably stunt tree growth before a disk can be used. With young trees, 1- to 5-years old, rye must be disked next to the trees at the proper time. However, the middles can be allowed to go to seed and form more organic matter before disking.

Wheat. Wheat is handled similarly to rye, except that it has the advantage of growing more slowly in the spring, giving the grower a better chance to disk it under before it damages tree growth. The choice of rye or wheat, however, may depend upon the price of the seed.

Domestic rye grass (Lolium multislorum). Recently, this crop has been widely used in the northern states for a winter cover crop. When seeded the middle of August, it makes enough fall growth to give ample soil cover for protection during the winter. Although it makes abundant root growth, it does not form as much top growth in the fall as common rye and, therefore, does not necessitate a cutting preceding fall harvest of winter apples, as is sometimes true with earlier planted rye. In the spring, its growth is not as rapid as rye and gives the grower an opportunity to disk it in before it competes with the trees. It has a dense root system which makes up for less top growth. There has been relatively little winter killing of this crop under Michigan and Pennsylvania conditions.

Winter vetch (Vicia villosa) and rye. This makes an excellent winter cover crop because if there is a good stand of vetch, the combination produces a heavy tonnage which is relatively high in nitrogen as compared with rye alone. The winter vetch will grow in seasons which are too dry for clover and on soils too acid for a good stand of clover and alfalfa. It makes more growth in cool weather than most legumes. The price of the vetch seed, however, in some years makes it prohibitive. When vetch is used alone, it should not be plowed under until the latter part of May due to the fact that it makes slow growth in spring. The plant will reseed itself from year to year.

Oats. Oats should be sown about mid-August in order to attain sufficient growth before the first freeze. In the North, oats are killed by the first heavy frost. This cover, although dead, will furnish good protection for the ground over winter. The crop is best adapted to a cool moist climate and a slightly acid soil. Oats will usually over-winter in the southern regions.

Crimson and red clover. If good stands of crimson clover can be obtained, it makes a desirable cover crop, but it tends to kill badly in regions where freezes are severe. It withstands the winter somewhat better if seeded in July. Red clover and mammoth clover are good cover crops where the soil is sweet and good stands can be secured. Cost of seed may be high.

Sweet clover (Melilotus alba and *M. officinalis).* Sweet clover is a valuable cover crop in the young orchard, provided it is kept a good distance from the trees due to the fact that it is deep-rooted and may compete with the trees for water in times of stress. It can also be used in a mature orchard where large quantities of humus are needed. Some growers make it a practice of sowing about 15 pounds of unscarified seed on wheat in January. Then shortly after the middle of March, five to six pounds of scarified seed are sown per acre. The crop should be disked down early the following year in about May to avoid competition for moisture with the trees. Biennial sweet clover has been used in Washington for a permanent cover, partially reseeding itself and resulting in a definite improvement in the physical condition and fertility of the soil. It is a tall grower, however, and sometimes interferes with spraying and other orchard operations. Its best adaptation appears to be in regions where irrigation is practiced, and there is not likely to be competition between the cover crop and trees for water.

In New Jersey, it is recommended that white sweet clover be sown August 1 to 15 and plowed under at a height of about 13 inches the following May in alternate rows, leaving every other row to reseed itself.

Alfalfa (Medicago sativa). Alfalfa can be used for a cover crop the same as sweet clover, but the price of seed has discouraged its use as an annual cover crop. Alfalfa is more valuable as a permanent cover, serving alone (Figure 65) or with clover and grasses as recommended previously for a permanent sod. It will take considerable rough treatment with machinery. Alfalfa alone as a permanent sod is the leading perennial legume in western orchards where irrigation is available. Irrigation is needed because this plant is deep-rooted and may compete heavily with the trees for water during dry periods. Once established, it has lasted as long as 18 years in one Washington orchard, although in some regions it may need to be reseeded every four to six years. It requires a good seedbed.

Alfalfa frequently harbors the buffalo tree hopper which lays its eggs in one-eighth-inch slits in the young bark. If abundant, this injury stunts shoot growth considerably, especially on trees under about five years. Strip cultivation next to the trees reduces the injury.

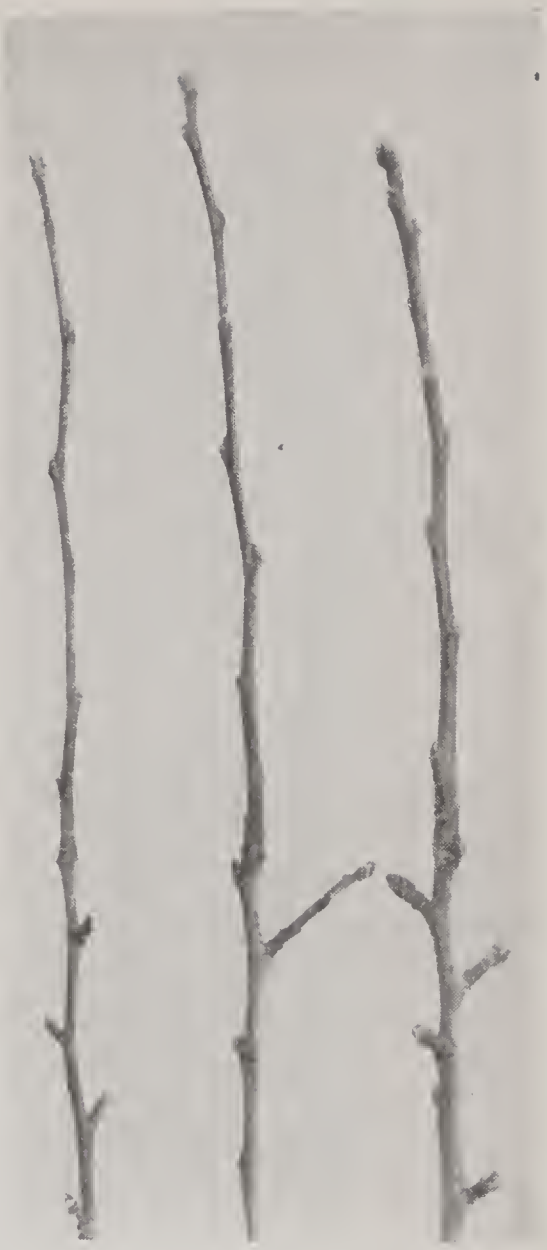
Weeds. Where a good even crop of weeds can be obtained, they are a good source of organic matter. However, many growers object to the untidy appearance with the tall stiff stems standing during the picking season. This can be corrected to some extent by mowing once or twice a season when the weeds reach about two feet in height. Incidentally, weed growth is an index of soil fertility. If weeds grow poorly, it is a sign that fertilizer will be needed to get good stands of cover crops.

FERTILIZING THE APPLE ORCHARD

The nutrients in the soil are first dissolved in the soil water and then absorbed by the fruit trees through the fine root hairs at the tips of the rootlets. Among the more important elements absorbed are nitrogen, phosphorus, potassium, magnesium, calcium, sulphur, and iron. Boron, zinc, manganese, copper, and several additional elements are considered of minor importance because they occur in most soils in sufficient quantities. However, if any one of these elements becomes deficient, growth and production are either limited or almost stopped.

Nutrients needed in orchards. For apple orchards in the United States as a whole, *nitrogen* is the element which becomes deficient first and which, when applied, gives the quickest and most pronounced response in growth and fruiting. This is because the nitrates, chief form in which trees utilize nitrogen, are easily leached out of the soil. Of course, orchards cannot grow and produce satisfactorily without other essential elements such as phosphorus and potassium. Most experimental data, however, have shown that fruit plants growing under average soil conditions obtain enough of these elements, and that it is difficult or almost impossible to show responses in growth and fruiting with applications of phosphorus or potassium. This is probably due to the fact that these elements are more stable and exist in sufficient quantities below the surface few inches of soil. An apple tree will root almost as deeply as the soil will permit, in some cases 25 to 30 feet. Thus, the roots of a mature tree have an extensive feeding area which annual crops such as corn, timothy, and clovers do not have. Also, much of the nutrient materials required for early season growth in apple trees are stored the previous season in the buds, wood, and bark of both the tops and roots. These stored foods are readily available when growth starts in spring. In annual plants, on the other hand, the only stored food available when spring growth starts is the small amount in the seed. It is not surprising, therefore, that an annual crop such as corn may show a very marked response to applications of phosphorus and potassium, while fruit trees on the same soil show little or no improved growth.

There are limited areas in the United States where applications of potassium have brought about better growth and production of apple trees. The areas are somewhat spotty and may lie in a 100-mile strip along the Atlantic Coastal Plain from Florida to Maine. On the light soils in New Jersey, applications of calcium (lime) as well as potassium are recommended in some areas. In sections of New York and New England, magnesium has been found to correct a leaf scorch, and in the Champlain Valley of New York, boron has been a definite corrective measure for bronzing and rosetting of the leaves. Applications of zinc sulphate to the soil or in holes in the trunk, or from nails driven into the trunk, have given control of "little leaf" and "rosette" on several different fruits in California, including the apple. Generally, the lighter or more sandy the type of soil, the more likely the need for a complete fertilizer, containing nitrogen, phosphorus and potassium, and perhaps other elements in special cases.



M. A. Blake, New Jersey Agr. Exp. Sta.

Figure 74. Shoot thickness is as important as shoot length in judging vigor of trees. Note the thick shoot and the plump fruit buds on the spurs of the Delicious wood at the right. Thin weak wood and spurs which contain mostly leaf buds are shown at the left. Wood of intermediate vigor is shown in the middle. Nitrogen fertilization would probably benefit growth of the trees from which the two left twigs were taken.

Does the orchard need fertilizer? The trees do not need fertilizer applications if the leaves are large, plentiful, and dark green, the shoot growth is thick and relatively long for the age of the tree (Figure 74), and the fruiting is fairly regular and satisfactory in size and quality. With a mature bearing apple tree, shoot growth at the tips of the branches should be at least six to ten inches annually, preferably 12 to 14 inches. Terminal growth for young nonbearing apple trees should be from 15 to 30 inches with the longer growths on the younger trees. The trunk and scaffold limbs should be thick and stocky with a dark greenish-brown color and only a moderate amount of scaliness of the bark. The amount of growth and the number of leaves on the spurs are important indications of the vigor of the tree. The nonbearing spurs in good condition should make from one-half- to three-fourths-inch growth in length and should have from six to ten healthy leaves.

If the trees under question do not meet the above qualifications for good vigor, the difficulty may be due to a limited supply of one of the following elements, deficiencies of which have been reported for apples in the United States.

Nitrogen deficiency symptoms. Shoot growth short and thin; leaves small, erect and light green or yellowish in color, dropping early, and showing somewhat more red color in the veins in autumn; bark light brown to yellowish orange in color; fruit small and highly colored with crop relatively light.

Potassium deficiency. Marginal and tip burning of the leaves; failure of lateral buds to unfold; short thin shoot growth; reduced size, color, and quality of the fruits. Potassium deficiency is more likely to occur on light soils, or shallow poorly drained soils, or in old orchards where the soil has been exploited by the root system.

Phosphorus deficiency. Dark grayish-green foliage and stems, restricted shoot growth and size of leaves; death of buds; and dull unattractive fruit which is lacking in firmness.

Magnesium deficiency. The leaves show some chlorosis and an interveinal scorch which may extend to the margins. This appears suddenly in midsummer and progresses rapidly from the base toward the tip of the shoots. The basal leaves usually absciss in late summer while the tip leaves persist. On old bearing trees the scorch is generally more uniform on all the foliage.

Calcium deficiency. Restricted root growth, brown root tips; death of the growing shoot tips; chlorotic browning and breakdown of large spots in the centers of the leaves; symptoms have been reported on trees growing in the lighter sandy soils.

Boron deficiency. Water-soaked exuding spots occur in the bark near the growing tips where they enlarge, turn brown and girdle the tips, causing death of leaves beyond the girdle; bark eventually becomes rough, cracks, and has corklike patches; some shoots develop leaf "rosettes"; poorly developed root system; fruit shows sunken corky areas near the skin and core, falls prematurely.

Zinc deficiency. Small mottled abnormally shaped leaves near the shoot tips which bunch together and form rosettes; reduced number of fruit buds, some "dieback" of shoots.

Amount of fertilizer needed. It should be stressed that fertilizer will not overcome fundamental difficulties of poor drainage or otherwise unfavorable soil conditions which frequently cause low vigor and low fruit production. The amount of fertilizer to apply to an orchard will depend upon the amount of shoot growth obtained, the yield and quality of fruit, the soil type, and whether the soil is in permanent sod or under some system of cultivation. Each orchard presents a different problem. Trees on the lighter

TABLE 9

COMMON SOURCES OF NITROGEN ON THE MARKET AND THEIR RESPECTIVE PERCENTAGES OF ACTUAL NITROGEN

SOURCES OF NITROGEN	COMPOSITION (PER CENT)
1. Uramon	42 to 46, nitrogen
2. Ammonium Nitrate	32.5 to 36, nitrogen
3. Cyanamid	20.5 nitrogen
4. Sulfate of Ammonia	20 nitrogen
5. Nitrate of Soda	16 nitrogen
6. Calcium Nitrate (Nitrate of lime)	15 nitrogen, 28 lime
7. Nitrate of Soda-Potash (Sodium and Potassium Nitrate)	14 nitrogen, 15 potash
8. Nitrate of Potash (Potassium Nitrate)	13 nitrogen, 44 potash
9. Ammo-Phos. A (Diaminonium phosphite)	11 nitrogen, 48 phosphoric acid

sandy types of soil require more fertilizer than trees on the heavier soils. Orchards with sod growing beneath the trees will require more fertilizer, especially nitrogen, than trees under mulch or cultivation. For an unmulched bearing apple tree with a 40-foot spread, about one extra pound of nitrogen will be needed for the grass in addition to that required by the tree. If it is desired to produce more mulch between the trees, the application must be increased accordingly. The nitrogen stored in the green grass is readily available to the tree if the sod is cut frequently.

Under sod conditions, the recommended amount of fertilizer for apples per year, using sulfate of ammonia or cyanamid, is one-fourth-pound for each year of age of the tree. Thus, a 12-year-old tree should receive about three pounds of sulfate of ammonia. If the tree is small for its age, application is made on the basis of the thickness of the trunk. The diameter of the trunk is divided by two, which gives the number of pounds of sulfate of ammonia to apply. For example, an apple tree measuring ten inches in trunk diameter would receive five pounds of sulfate of ammonia.

Table 9 gives the various sources from which nitrogen can be obtained. The first five listed in the table are the more common sources of nitrogen in orchards. The chief consideration in deciding what form of nitrogen to use is the relative cost per pound of nitrogen. Nitrate of soda is more quickly available to the plants but often is the more expensive. Ammonium sulphate is somewhat slower in action and tends to make the soil more acid in the upper few inches. This can easily be corrected by applying 110 pounds of lime for every 100 pounds of ammonium sulphate. In recent years, cyanamid has been a relatively cheap source of nitrogen, but it is slower in action because much of the ammonia nitrogen must be changed by soil bacteria to the nitrate form before it is available to the tree. Cyanamid has caused leaf burning to trees growing in the lighter soils when applied in the spring. Fall application is recommended under light-soil conditions and very early spring under other soil conditions. Cyanamid carries over 50 per cent lime which is valuable in neutralizing soil acidity.

During the recent war period when nitrate of soda and sulfate of ammonia were scarce or unavailable, ammonium nitrate and Uramon were extensively used in orchards. Both proved satisfactory. However, due to the fact that their storage qualities were not ideal, the orchardist was encouraged to apply them as soon after received as possible, whether in fall or spring. The nitrogen content of these fertilizers is relatively high and, therefore, less quantity is needed per tree. For ammonium nitrate, two ounces are applied for each year of age of the tree. Thus, a 16-year-old tree would require about two pounds. When calculated on the basis of the thickness of the trunk, the trunk diameter is divided by four giving the amount of fertilizer in pounds to apply at one application. For example, an apple tree measuring ten inches in trunk diameter would require two and one-half pounds of ammonium nitrate for a single application. About half as much Uramon is applied as is required for sulfate of ammonia.

Continued applications of both ammonium nitrate and Uramon tend to increase soil acidity. For each 100 pounds of these fertilizers applied, about 58 pounds of lime is required for ammonium nitrate and 75 pounds for Uramon to maintain an even soil acidity. It may be advisable to have samples of the soil checked every few years by state agencies, and then apply the recommended lime to raise the pH to between 6.0 and 6.5, mainly for the benefit of the sod or cover crop if a legume is involved. Accumulation of sulfur in the soil from sprays is also a factor in increasing soil acidity.

The latter four sources of nitrogen in Table 9 are usually more expensive for they contain other elements in addition to nitrogen. No striking superiority has been shown for nitrate of potash, although some people recommend it as being desirable. The disproportionate amount of potash in relation to nitrogen can be corrected by using, in addition, a nitrogen-carrying fertilizer.

Table 9 shows the approximate amount of sulfate of ammonia to apply, depending upon age of tree and soil management system. More or less of the other nitrogen-carrying fertilizers can be used in accordance with their actual nitrogen content.

Where an application of superphosphate (20 per cent phosphorus) is desired, it is applied at the same rate as sulfate of ammonia. Muriate of potash (KC1) is applied at the rate of about two-thirds to three-fourths that of ammonium sulphate. In a 15-year-old orchard, if three and three-fourths pounds of sulfate of ammonia, three and three-fourths pounds of superphosphate, and two and three-fourths of muriate of potash are applied, the total applications would amount to 250 pounds of complete fertilizer per acre applied to the trees only. If the area between the trees is fertilized in addition, it would require about 835 pounds per acre. If a ready-mixed complete fertilizer is used in an all-over application, it is applied at the rate of approximately 800 pounds per acre.

Manure of any kind is usually classified as a nitrogenous fertilizer, although it carries about as much potash as nitrogen, and is low in phos-

TABLE 10

APPROXIMATE AMOUNT OF AMMONIUM SULPHATE TO APPLY TO APPLE TREES OF DIFFERENT AGES, VIGOR, AND SOIL MANAGEMENT SYSTEMS[1]

AGE OF TREES	IN SOD		CULTIVATED	
	Good Vigor	Low in Vigor	Average Vigor	Low in Vigor
Years	*Pounds*	*Pounds*	*Pounds*	*Pounds*
1 to 2	⅛ to ¼	¼ to 1	0 to ¼	¼ to ½
3 to 5	1 to 2	1½ to 3	¼ to ½	½ to 2
5 to 10	2 to 3	3 to 4	½ to 2	2 to 3
10 to 15	3 to 5	4 to 6	2 to 3	3 to 4
15 to 20	5 to 7	6 to 8	3 to 4	4 to 6
20 to 25	7 to 9	8 to 12	4 to 6	6 to 9
25 to 30	9 to 12	12 to 16	6 to 8	9 to 10
Over 30	12 to 15	16 to 20	8 to 10	10 to 12

[1] If nitrate of soda is used, apply 5 per cent more by weight.

phorus. Manure used in field experiments at Pennsylvania State College was computed to carry the equivalent of 9.8 pounds of nitrogen, 2.82 pounds of phosphorus, and 7.14 pounds of potassium per ton. These figures vary for different manures and other factors. It requires about 20 times as much manure by volume to furnish the same amount of nitrogen as in sulfate of ammonia. Also, nitrogen in manure becomes available to the trees more slowly than the commercial forms and, for this reason, it seems advisable to make a light application of manure in early spring in combination with sufficient soluble nitrogen to meet the requirements. If a plentiful supply of fresh manure is applied in spring, the general result is insufficient available nitrogen for fruit set and, more important, too much nitrogen becomes available late in the growing season, causing poor fruit color and immaturity of wood. Poultry manure is higher in nitrogen than most manures. The chief disadvantage of manure is the fact that it is expensive and difficult to obtain in sufficient quantities.

Time for application. Nitrogen fertilizers will do the most good if applied about two to three weeks before the buds begin to swell in spring. This gives the nitrogen ample time to be absorbed and transferred to the spurs and shoots, resulting in early development of large leaves, good shoot growth, good set of fruit and rapid development in fruit size. If a heavy bloom is expected, however, it might be well to delay nitrogen application until after bloom in order to help reduce the fruit set and the amount of hand labor needed for fruit thinning in July. In general, it is better to apply too early than too late.

Experimental evidence has shown little or no difference in tree response with fall or spring applications of fertilizer. In fall, it should be applied before the first of December or before the ground has become frozen. The season of application is not so important as an adequate amount of fertilizer.

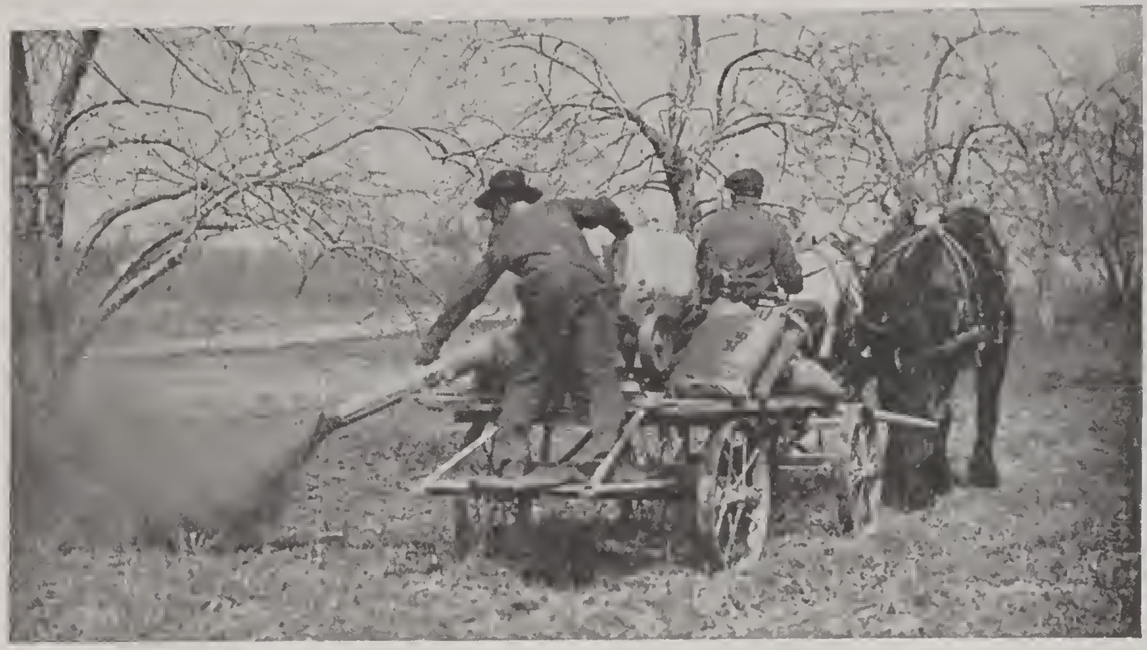
The question is often asked regarding a split application of nitrogen, half in spring and half in late summer. In all probabilities, if half of the fertilizer is applied in spring and the blossoms utilize this amount with little or none left for the expanding leaves, the leaves will suffer and not attain their normal development in size. A restricted leaf growth early in the season will naturally restrict fruit bud formation and normal development of fruit size. Also, the later the fertilizer is applied in the season, the more likely it is to delay maturity of the wood and fruit and reduce red color of the fruit.

If little or no nitrogen has been applied in the spring and it becomes apparent during the middle of the season that the fruits are inferior in size, fruit size may be influenced by a medium to light fertilization in July or August, but such a procedure should be regarded as exceptional. Late summer applications have sometimes been practiced with trees low in vigor and those which do not contain a crop. The application is made between August 15 and September 1 after the terminal buds have formed on the shoots. Such an application increases the rate of food manufacture by the leaves and, therefore, increases the amount of food stored in the tissues over winter. An abundance of stored food tends to produce a large leaf surface early the next spring which, in turn, may increase the set of fruit in that particular year and help to reduce alternate bearing in subsequent years.

Method of application. The general practice is to apply fertilizer in a band or ring around the tree under the spread of the branches. No fertilizer should be applied within two to three feet of the trunk due to the fact that relatively few feeding roots are in this area. The fertilizer is dissolved and enters the soil with the first good rain. For this reason, it is important to apply the fertilizer two to three weeks before bloom in order to give ample time for a rain to fall before the buds begin to open.

Where feasible, application of fertilizer by machinery is more rapid and labor saving than by hand. Any type of machine can be used which gives an even distribution of fertilizer. Fruit growers report satisfactory results with endgate distributors, lime drills, grain drills, and power dusting machines. In case of endgate distributors, the wagon or truck is driven up the row middles, and the material is broadcast over the entire area. Where the land is suitable, some growers apply in one direction one year and in the cross direction the next. When grain drills and lime spreaders are used, the material is applied in a band on each side of the tree row. After a few bags are applied and the machine adjusted, the grower can rather accurately estimate how much is being applied per tree. When applications are made on an acre basis, the operator applies the desired amount to the acre and then returns later to a few scattered trees or "resets" that need special attention.

Where a power dusting machine is available in the larger orchards, they are quite satisfactory for applying fertilizers, as shown in Figure 75. The fertilizer is evenly and quickly applied at a considerable saving in labor. It is well to select a calm day. The discharge spout should be held close to the



American Cyanamid Co., New York City

Figure 75. Power dusting machines offer a quick and economical method for applying fertilizers. Openings in the discharge plate should be enlarged four or five times the original in order to keep the team or truck moving at a good pace. The fertilizer needed for a tree is applied half on one side and half on the other.

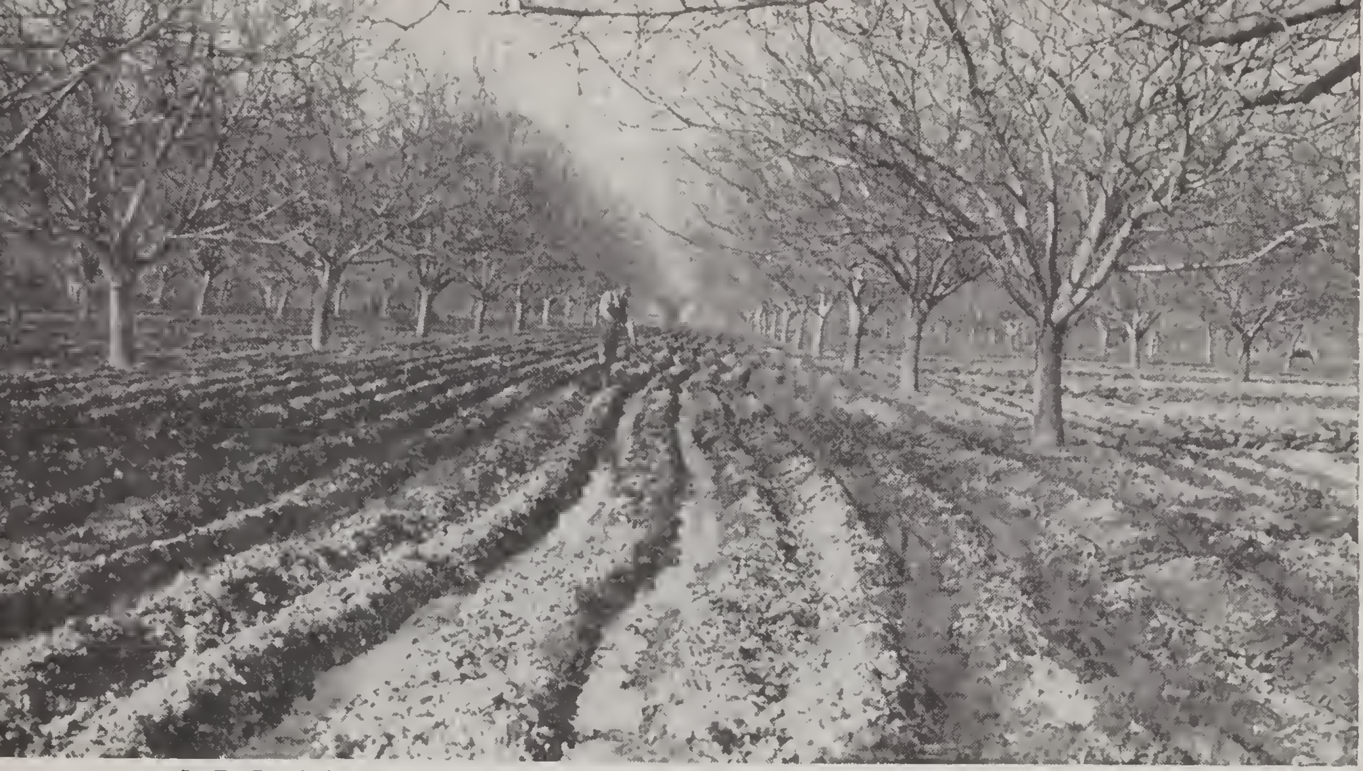
ground and well away from the area to be covered. The draft of the blower carries the material evenly over the desired area. A small piece of tin in the form of a lip placed over the mouth of the discharge spout aids in directing the flow of the fertilizer to the ground. An "elbow" placed over the mouth and directed toward the ground will have the same effect. The machine can be shut off for "skips" and small replants.

Special fertilizer distributor attachments for adapted truck beds are now available for rapid commercial fertilizer distribution. These are powered by the truck motor as the truck moves at a slow gait. Airplane distribution of commercial fertilizers is also being practiced in tung and citrus orchards.

Fertilizer can be distributed by hand using calibrated tin cans, buckets, or a specially made hand distributor sold on the market. The specially made distributor is more rapid than by hand, spreads the fertilizer more evenly, and prevents caustic fertilizers such as cyanamid from coming in contact with the skin. Also, special care must be taken to keep the fertilizer out of the eyes, and to remove it from the hands at the end of the day by using a common lubricating oil followed by soap, and more oil, if necessary. Kerosene or gasoline should not be used as a cleanser.

The supply of fertilizer for the orchard can be placed in a tight box on a sled, a low-wheeled wagon, or a low truck. The fertilizer is applied in a sweeping motion as with the cutting stroke of a grass scythe. It is best to spread with the wind so that the material is scattered more evenly on the desired areas.

Orchard irrigation. Orchard irrigation has not been generally practiced for apples in the eastern United States due to the fact that rainfall in most years is sufficient for these deeper-rooted fruit plants. Heavy mulching and



L. D. Batchelor, University of California

Figure 76. Furrow irrigation is common in the West, provided the water will move into the soil readily. Good penetration and reduction in runoff can be obtained by periodic check-furrows which guide the water in U's back and forth across the long furrows.

other practices for conserving moisture have often been more economical in tiding the trees over the dry periods. Irrigation might be considered in heavy shallow-rooted soils if, in spite of mulching, fruit thinning, and other standard practices, the trees are making less than eight to ten inches annual terminal growth and producing small-size, poor-quality fruit. It would be well, however, for the grower to study local U. S. Weather Bureau rainfall records and determine the frequency of droughts for his region. An irrigation system is of questionable value if it can be used only once in five years.

The first requisite in orchard irrigation is a plentiful supply of water from a near-by river or stream which does not go dry during the most extensive drought periods. It is not worthwhile to irrigate with less than two inches of water per acre each time, which requires 54,000 gallons. Water from wells is usually not adequate for extensive orchard irrigation. Methods which have been used in the East for supplemental irrigation are furrow, basin (a shallow square pond beneath each tree, fed by a furrow), sprinkler, and porous and eyelet hoses. A fairly satisfactory method used in the East for determining when and how much water to apply is to study the average monthly rainfall records for the area. When rainfall becomes definitely deficient, two- to three-acre inches of water are applied in each application as needed.

Orchard irrigation is a common practice in western regions where rainfall is deficient. Sufficient water must be supplied to secure thrifty but not extensive or rank wood growth. Excessive irrigation may be disastrous. Light sandy soils or soils underlain with a substratum of gravel require more frequent and heavier applications of water, while the heavy clay loams may need only one or two applications. More irrigation water is needed in an area where the evaporating power of the air is high than where it is low.

It is important to get even distribution of water and good penetration. The furrow system is common in the West for irrigating where six to eight large furrows, six inches or more in depth are made between every two rows of trees, as shown in Figure 76. The contour-check system of furrow irrigation is best adapted to the foothill and mountain sections.

Most authorities agree that the soil should be wetted to a depth of about three feet for the heavier soils and to about six feet for the lighter soils, or the area in which most of the tree roots occur. For a loam to clay-loam type of soil, as an example, this would require around 100,000 gallons per acre per application. As much as 30 to 35 inches of annual irrigation water is applied in some regions in addition to the rainfall. Frequent examination of the soil with an auger is the most satisfactory method in the West for determining the necessity for and the frequency of irrigation. It requires technical assistance to properly estimate when and how much water to apply. References are given at the end of this chapter for more detailed recommendations on orchard irrigation.

Review Questions

1. Why does a young apple orchard require a different soil management system than a mature bearing orchard?
2. Outline a soil management program for 1-year apple trees planted on the square on gently rolling, relatively heavy soil.
3. Outline a soil management program for 1-year apple trees on a moderately steep slope (25 per cent).
4. What are the advantages of sod mulch with additional mulch for mature bearing apple trees?
5. Discuss a poisoning program for field mice in sod-mulch orchards.
6. What is the value of a "ground ripper" or "weed hog" in the mature orchard?
7. List the advanatges of an orchard cover crop in young apple orchards.
8. List 5 summer and 5 winter orchard cover crops which you think would be adapted to your local soil and climatic conditions; discuss one of each.
9. What is the chief disadvantage of rye as a cover crop?
10. In apple orchards, what nutrient receives most attention in the fertilization program, and why?
11. How much fertilizer would you apply to a 20-year apple tree growing in medium-heavy soil in sod with no mulch, and making annual terminal growth of from 2 to 3 inches?
12. What percentage nitrogen do the following fertilizers contain: sulfate of ammonia, nitrate of soda, cyanamid, and ammonium nitrate?
13. What effect do continued applications of the above fertilizers have on soil acidity in the upper few inches of soil?
14. Would you advise orchard irrigation in your region, considering information given in Chapter III on regions and the suggestions in this chapter?

Suggested Collateral Readings

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CHAPTER VI

Flower-Bud Formation, Pollination, and Fruit Set in the Apple

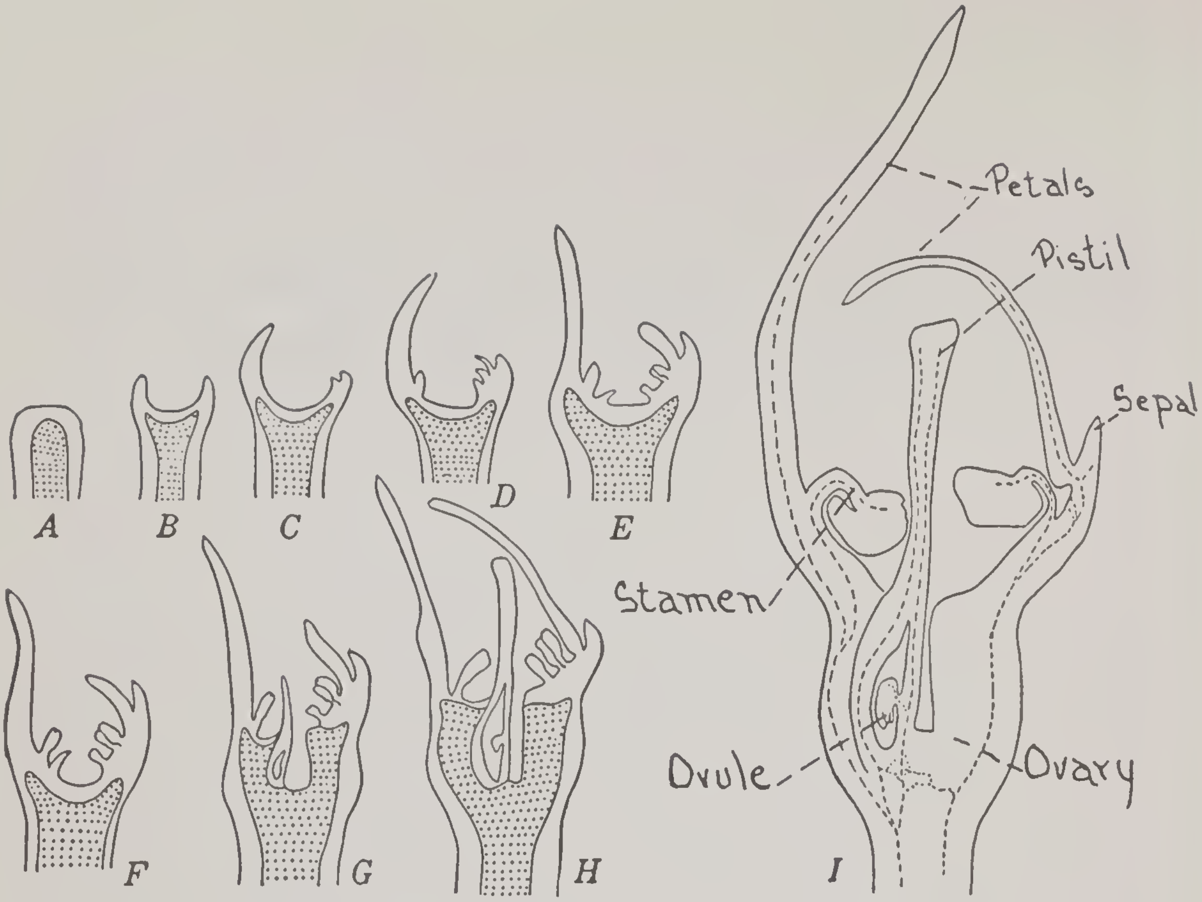
FLOWER-BUD FORMATION

Time and manner of fruit-bud formation. In temperate zones, the flower buds of fruit trees are more or less well developed the season *previous* to their unfolding into blossoms. The exact time when initiation of flower buds occurs in the apple varies somewhat with the geographic region and the variety. The gradual development of an apple flower bud is shown in Figure 77, starting in June of one year and reaching completion in the spring of the following year. In general, the outside parts of the flower bud develop first, and the inside last.

The observations of A. W. Drinkard on flower-bud development in Virginia are similar to those diagramed here. The variety of apple which he used was Duchess of Oldenburg. First indication of flower-bud primordia was noticed between June 15 and 30; calyx lobes were seen, June 30 and July 7; anthers, July 7 and 14; pistils, August 7 and 14; cavities of the ovaries where the ovule is located, September 15 and 30; flower petals near base of calyx, November 15; ovules did not appear until March; mature pollen was evident in March; and differentiation of the flower was complete by April 1 shortly before it opened into a blossom.

From the above information, it is evident that June or July is the period during which it is determined whether an apple bud will be a flower bud or a "vegetative" growing point without flowers. One should bear in mind, therefore, that any cultural treatment to induce flower bud formation during these months must be performed during the previous spring or fall.

Factors affecting flower-bud formation. From a physiological standpoint, it has not been well established as to the exact factors associated with flower-bud formation in the apple and other pomological fruits. Many horticulturists and plant physiologists have explained flower-bud formation on the basis of relative amounts of carbohydrates and nitrogen in the plant tissues. While this theory appears to be a logical explanation in that a certain balance between carbohydrates and nitrogen has been found to be correlated with flower-bud differentiation, there is insufficient clear-cut evidence at this



Hayward "The Structure of Economic Plants"

Figure 77. Diagrams show the development of a flower bud of the apple, beginning at *A* in about mid-June and extending to the following April at *I*. The outer parts of the flower appear first, the inner parts last.

time to fully substantiate it as a causal relationship. The concept has developed largely on the basis of work done with the tomato by E. J. Kraus and H. R. Kraybill who show by extensive chemical data the effects of different carbohydrate nitrogen relationships in tissues on fruit setting but not on flower-bud formation. In the original work four classes were designated into which a tomato plant might be placed according to its vegetative and fruiting responses. These classes might be arbitrarily repeated for the apple, as shown in Table 11. An apple tree which has been heavily nitrated would be placed in Class II, whereas a neglected tree growing in sod would probably fall in Class IV. Note that high carbohydrates and high nitrogen are respectively symbolized by large "C" and large "N," whereas low carbohydrates and low nitrogen are designated respectively with a small "c" and small "n." Intermediate amounts are symbolized by letters intermediate in size.

There is increasing evidence that hormones are important in flower-bud formation. In fact, scientists in this field of research are inclined to place more emphasis on hormones or growth substances as a factor inducing flower-bud initiation than on the carbohydrate nitrogen concept, although the importance of the latter still may not be fully revealed. These growth substances, the chemical nature of which is unknown, are apparently formed

TABLE 11

THE INFLUENCE OF DIFFERENT AMOUNTS OF CARBOHYDRATES AND NITROGEN IN TREE TISSUES ON THE GROWTH AND FRUITING

CLASS	RELATIVE AMOUNTS OF "C" AND "N"	AMOUNT OF VEGETATIVE GROWTH	AMOUNT OF FRUIT	SITUATION DUE TO
I	$\frac{\mathrm{C}}{\Large\mathrm{N}}$	poor	small or none	Defoliation by insects, diseases, sprays, or continued excessive summer pruning.
II	$\frac{\large\mathrm{C}}{\large\mathrm{N}}$	rank	small	Too much nitrogen fertilization or too heavy pruning, or both.
III	$\frac{\Large\mathrm{C}}{\mathrm{N}}$	moderate	good	Judicious fertilization, pruning, fruit thinning, soil management, and spraying.
IV	$\frac{\LARGE\mathrm{C}}{\small\mathrm{N}}$	poor	small	Insufficient nitrogen often found under sod management with little or no attention to nitrogen applications

in the leaves and transported to and concentrated in the regions of the plant where flower buds are formed. Future research may indicate more clearly the exact nature of these substances which together with the carbohydrate food supply are influential in the initiation of flower buds. The fact still remains, however, that flowers and their end products, such as fruit and seed, are composed largely of the products of photosynthesis and of the organic nitrogen complexes. Thus, the green leaves are no doubt of utmost importance in governing flower-bud formation and should be guarded closely against injury from insects and diseases, caustic spray solutions and other agents which may tend to lower their efficiency.

There are several environmental factors under field conditions which are known to stimulate or depress flower-bud formation. These will be discussed briefly in the following paragraphs.

Under natural conditions, *light intensity* is the most important environmental factor governing the rate of carbohydrate manufacture in leaves. It is important especially from the standpoint of amount of light reaching the foliage in the center of trees. With dense trees, low light intensity is one of the chief reasons for few flowers being borne in the centers of the trees. The practice of opening the top of trees by *pruning*, therefore, admits light to the centers and tends to increase flower-bud formation in this region. On the other hand, *excessive pruning* reduces the foliage to such an extent that the roots are able to supply relatively large quantities of nitrogen and water to the remaining portion of the top, resulting in considerable shoot growth and water-sprouts with little or no flower-bud formation. *Root pruning,* or any injury to the roots as a result of cold, excessive moisture, deep plowing, or rodent injury, tends to temporarily increase flower formation. Root pruning reduces the root system and thus, limits the amount of water and nutrients available to the top, resulting in reduced shoot and spur growth. Such a retardation in top growth is usually associated with increased flower-bud formation, Root pruning is an amateur practice in Europe with the purpose of inducing young vigorous trees to bear earlier. It has not been commercially adopted in America.

Removal of leaves or defoliation due to injury by insects, diseases, or caustic sprays results in reduced flower-bud formation, especially if defoliation occurs prior to the period of flower-bud differentiation. In principle, this is due to a reduction in the carbohydrates available to the buds in the axils of the injured or destroyed leaves. A *deficiency of water* during the period when flower buds are forming may intensely stimulate flower-bud formation. However, if water deficiency is severe and the tree is already in weak condition due to poor cultural management or other reasons, flower-bud formation may be adversely affected. Application of *nitrogen fertilizers* in rather excessive amounts to young nonbearing trees results in tardy bearing, and, actually, the tree may go into rank vegetative growth for several years with little or no flower-bud formation. On the other hand, if the tree has been in low vigor, moderate nitrogen applications usually increase flower-bud formation.

Bending of limbs often results in increased flower formation beyond the bend. Back of the bend, however, new and vigorous shoot growth may be induced. The theory involved is that the bend restricts the movement of carbohydrates from the outer portion of the limb toward the roots. An accumulation of carbohydrates and slowing down of growth beyond the bend is, therefore, assumed to be favorable to flower-bud formation. Back of the bend, less carbohydrates are available, but more water and nitrogen from the roots are present, resulting in vigorous shoot growth in this area. Bending is sometimes practiced on vigorous young apple and pear trees to induce wide-angled crotches and earlier flowering. *Dwarfing rootstocks* on standard varieties usually cause the trees to bear much earlier in life. The dwarfing stocks reduce the rate of shoot and spur growth and consequently result in flower-bud formation.

Ringing is a special commercial practice that usually brings about increased flower formation. Ringing is defined as the removal of a thin strip of bark from around the trunk or at the base of main limbs. "Scoring" has a similar effect and consists of making two or more cuts to the sapwood around the trunk or limbs, but no bark is removed. Driving nails into the trunk or cutting out notches below buds influence flowering more or less the same as ringing. Likewise, injuries to the limbs, crotches, trunk, or roots due to low temperature, cankers, disease, fire, or rodents result in increased flower formation. If a wire label is left attached to a young tree, it becomes taut and eventually rings or constricts the tree, causing carbohydrates to accumulate above the wire; the top becomes weakened, and flower-bud formation takes place, providing the tree is older than about three years.

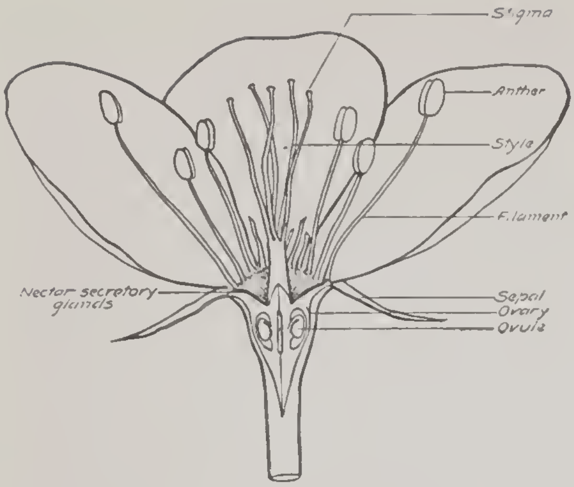
Ringing is a practice resorted to occasionally to increase flower formation on vigorously growing young trees which are tardy in bearing. It is also commercially practiced along with rather heavy pruning on filler trees which are beginning to crowd the permanent trees. Ringing is done about three to five weeks before flower-bud formation usually occurs; in New York and northern Ohio, this is latter May or the first part of June. A strip of bark one-eighth- to one-quarter-inch wide is removed from around the base of a few individual limbs. The entire trunk may be ringed but it seems preferable to ring a few main branches one year and the rest the next year. The wounds should be covered with electrician's tape, wax-muslin strips, or a similar substance which is not injurious to the plant tissues. This protects the wound from entrance of bacteria and other micro-organisms. The protective material should not touch the exposed wood. Shoots developing near the ring must immediately be removed to prevent entrance of the fire blight organism (*Erwinia amylovora*). Scoring can be used (two or three parallel cuts) and is about as effective as ringing.

The ringing should not be performed on very young trees, small limbs, more or less defoliated trees, trees in very low vigor, or on peaches, apricots, cherries, or plums. The ringing of alternate bearing trees cannot be expected to induce fruit production in the so-called "off" year. As pointed out earlier, the best commercial use of ringing is on filler trees which are being rather heavily pruned at the same time, in order to increase fruit production as much as posssible before the fillers are removed to make room for the permanents.

POLLINATION AND FRUIT SET

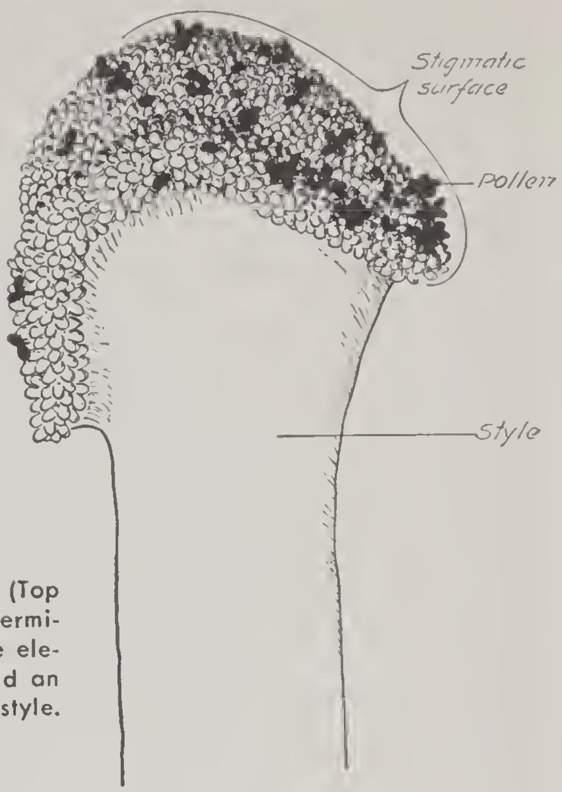
Before discussing pollination, one should first be acquainted with the essential parts of the flower. The stamen, or male organ, consists of two parts (Figure 78): (1) the anther, which is made up of two sacs containing the pollen grains and (2) the filament, or stalk which supports the anther. The three parts of the pistil, or female organ, are (1) the basal part or ovary which contains the young ovules and which, along with other parts, develops into the fruit, (2) the styles which are attached to the ovary and bear at their apexes the receptive sticky surfaces known as (3) the stigmas upon which the pollen grains are caught and germinate.

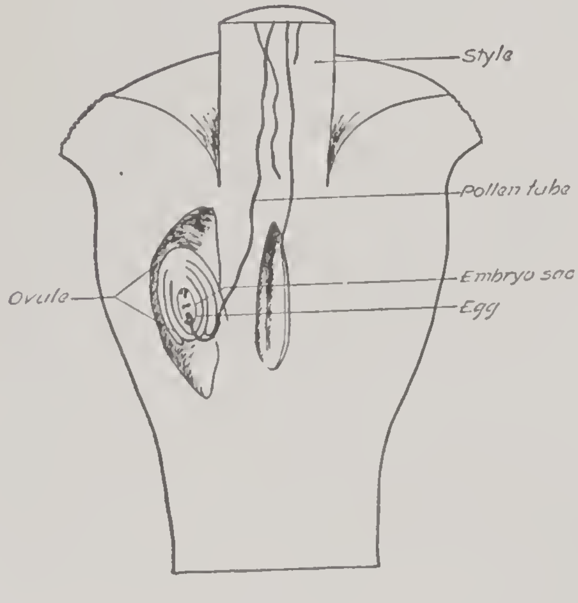
Once the flower has opened in the spring, it is necessary for pollination to take place in order for it to "stick" to the tree and begin to develop into a fruit. If limited or no pollination occurs, the flowers will drop, or develop into a small fruit that drops early. *Pollination* is defined as the transfer of the pollen grains from the anther to the stigma. If the transfer is from anther to stigma on the same flower or to the stigma of another flower of the same variety, it is known as *self-pollination*. If the transfer is from an anther of one variety to a stigma of another variety, it is known as *cross-pollination*.

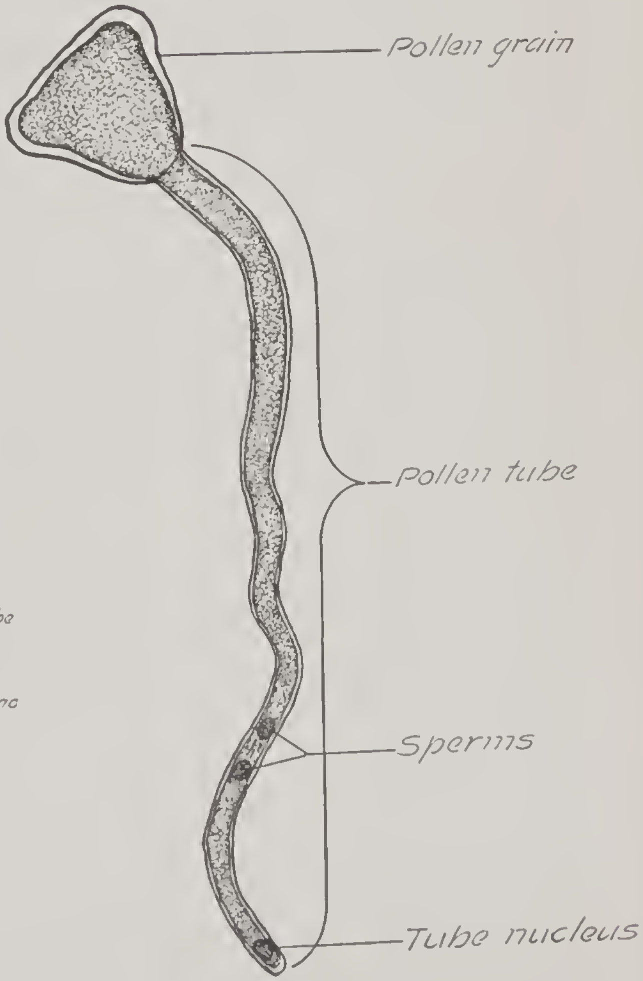


L. H. MacDaniels, Cornell University

Figure 78. (Top left) Apple flower and parts. (Top right) Stigma with pollen grains. (Bottom right) Germinating pollen grain. (Bottom left) Base of female element showing lower part of style, the ovary, and an ovule, with pollen tubes growing down through style.







The honeybee is probably responsible for over 90 per cent of the apple pollination; bumblebees and other wild bees may serve more effectively in pollination during windy or cold weather but usually there are too few of these insects.

Pollen grains of the apple and most fruit plants resemble minute yellow dust particles. They are round or roughly triangular in shape with a diameter of 1/1000 of an inch. Each anther contains about 3500 pollen grains, and since there are 20 stamens, this would be 70,000 grains per flower. Apple pollen is sticky and adheres to the hairy body of the honeybee as it visits the showy flowers in search of nectar. The nectar glands are located near the base of the stamens, as shown in Figure 78[1]. The number of pollen grains carried by a single bee might easily approximate 100,000. In visiting flower after flower, however, the bee rubs off pollen onto the stigmas and picks up additional pollen, bringing about self- and cross-pollination. Wind carries very little apple pollen. There is little or no flight of honeybees during rains and heavy winds, or if the temperature is below 65° F. Therefore, the number of sunlight hours during the blossoming period when the temperature is above 70° F. and the air is fairly quiet, are highly important.

The pollen grain germinates shortly after it comes in contact with the stigma (Figure 78), sending out what is known as a pollen tube. Germination and growth of this tube is faster when the temperature is above 70° F., but it probably is retarded at temperatures above 80° F. The pollen tube grows down the style until it reaches and penetrates the young ovule and finally finds its way to the place where the egg, or female organ, is located (embryo sac). During the growth of the pollen tube, the two male germs (sperms) are formed in the pollen tube. These are discharged into the embryo sac, where one of them unites with the egg, and by this process, *fertilization* is accomplished. Fertilization, or the union of egg and sperm, is quite similar, therefore, to that taking place in animals. When fertilization in the flower has taken place, there is an initial stimulation to the basal part of the flower tissues which prevents it from dropping.

While eating an apple, it may be noted that there are five compartments or carpels near the core which contain two, one, or no seeds. If pollination and fertilization have been good, the apple, therefore, may contain from a few to ten seeds, and such an apple will likely stick to the spur and mature. However, if pollination and fertilization have been inadequate due to poor weather conditions or other causes, only one to three seeds may develop. Seed development stimulates the apple tissue in the immediate vicinity of the seed. For example, if an apple contains three seeds on one side and none on the other, the tissues in the neighborhood of the seeds will grow

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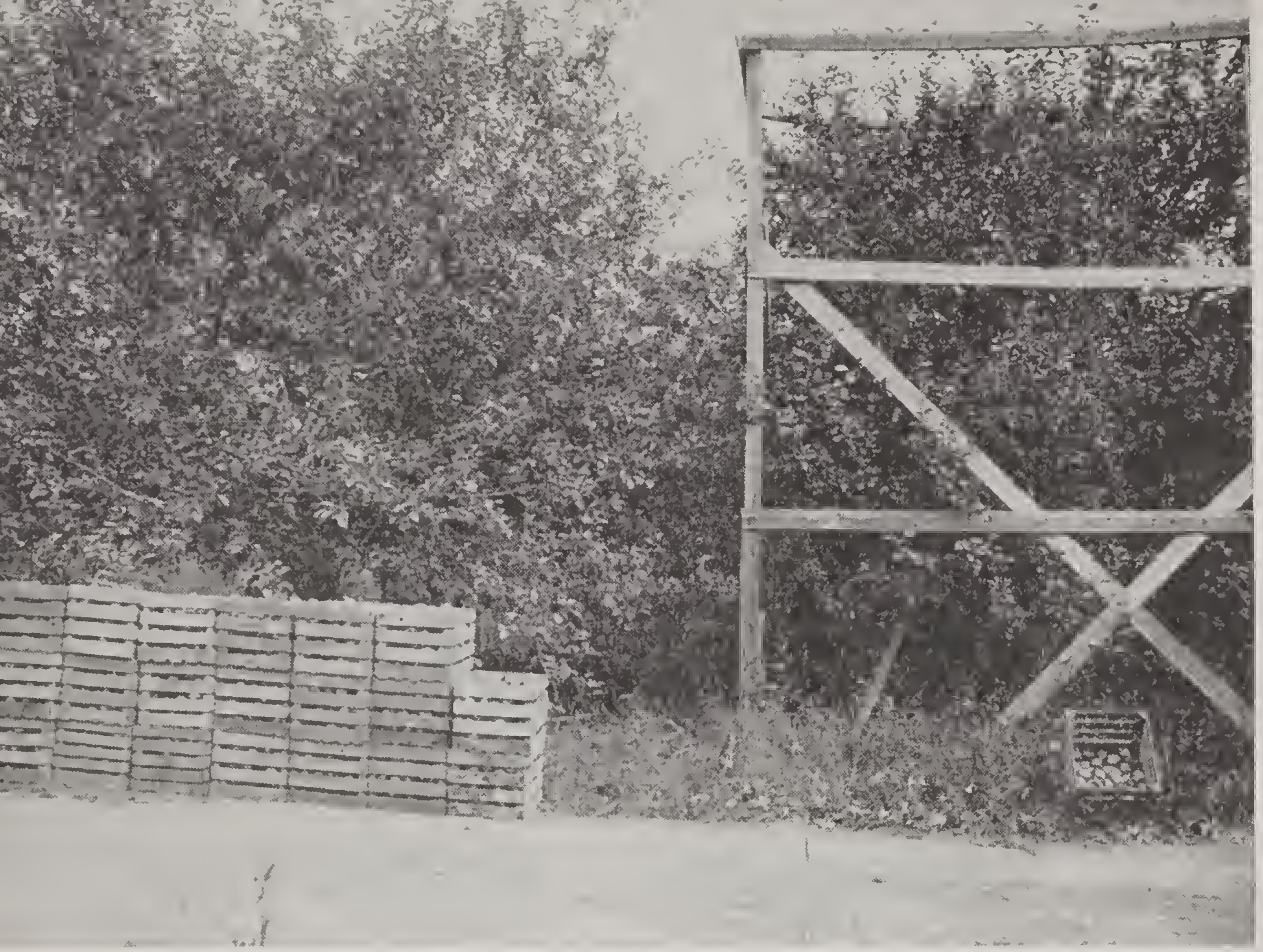
[1] It has been recently pointed out by R. H. Roberts at the Wis. Agr. Exp. Sta. that better pollination conditions are required for Delicious. The structure of the Delicious flower is such that the bee does not need to crawl over the anthers and stigmas in obtaining nectar. For this reason, there is some indication that hand pollination with this variety might be encouraged to obtain better sets.



A. J. Heinicke, Cornell University

Figure 79. Some apple varieties are self-unfruitful. The McIntosh on the left was cross-pollinated with insects and bore 23 bushels of apples. Insects were excluded from the trees on the right by cheesecloth netting, with the result that it bore less than one-half bushel of apples.

normally, whereas the other side of the apple will develop slowly and the fruit subsequently assume a lop-sided shape. Also, an apple with only a few seeds is more likely to drop to the ground before maturing, especially if there is considerable competition between the fruits for water, soil nutrients, and carbohydrates.

Some apple varieties will not set fruit by self-pollination. Much of the difficulty experienced in obtaining a set of fruit in orchards is due to the fact that many important varieties, as, for example, McIntosh and Delicious, will not form seeds nor set fruit when their blossoms are self-pollinated (Figure 79). Such varieties are known as *self-unfruitful,* and must have cross-pollination from another variety in order to set and hold their fruit. If a set of fruit results from self-pollination, the variety is said to be *self-fruitful.* Some apple varieties are considered *partly* self-fruitful but none, except perhaps Yellow Transparent, have produced full commercial crops of fruit year after year by their own pollen.

There are cases, such as the Delicious variety, where the pollen is viable or capable of germination, and the egg cells are normal, yet the variety will not set fruit after self-pollination. The variety, therefore, is said to be *self-incompatible,* as well as self-unfruitful. Some varieties may be *cross-incom-*

TABLE 12

APPLE VARIETIES WITH INFERTILE AND INEFFECTIVE POLLEN FOR SELF- OR CROSS-POLLINATION[1]

(Adapted from Gourley and Howlett)

Arkansas (Mammoth Black Twig)
Baldwin
Canada Reinette
Gravenstein, Red Gravenstein and Bank's
Hibernal
Minkler
Paragon (Arkansas Black)
Rhode Island Greening
Stark
Stayman Winesap, Stamared, Blaxtayman, and Scarlet Stamared
Summer Rambo
Tompkins King
Turley
Virginia Crab
Winesap

[1] All of these varieties have a triploid number of chromosomes which is closely correlated with this situation.

patible where fruit does not set, as for example, after Arkansas has been cross-pollinated with Grimes. They are also said to be *cross-unfruitful.*

It is apparent from the above discussion that when cross-unfruitful or self-unfruitful varieties are planted in large blocks with no other varieties in the neighborhood, the trees will not bear commercial crops of fruit, even though they may bloom profusely. In the old days when orchards contained as many as fifty varieties of apples interplanted together, there was little difficulty encountered from poor crops of fruit due to lack of cross-pollination. However, in more recent years when orchardists occasionally planted large blocks of single varieties such as McIntosh for convenience in management, difficulties immediately arose in obtaining commercial crops of fruit. This stimulated considerable experimental work over the country in the field of pollination and fruit setting. Trees were placed in cloth cages at blossom time, or individual branches or spurs were placed in cloth bags. In cross-pollination experiments, stamens of the enclosed flowers were removed before they shed pollen. Then by special technique, pollen from a different variety or the same variety was daubed with a camel-hair brush (hand-pollinated) on the pistils of the enclosed flowers to determine the percentage of fruit set. After several years of experimental work, the more common apple varieties listed above were found to have *infertile* pollen and consequently are *ineffective* in self- or cross-pollination.

Thus, if any one of the above varieties is used, the planting must consist of at least three varieties. The two other varieties must cross-fertilize each other in addition to the above variety. Pollen of commercial varieties not listed above is usually effective in cross-pollination. There are cases, however, where Grimes Golden is cross-incompatible with Arkansas and Paragon, Early McIntosh is a poor pollinizer for Cortland, and standard varieties are incompatible with their "bud sports." Seedlings are usually cross-fruitful with their parent varieties, except Rome Beauty and Gallia Beauty which are only partly cross-fruitful. Some varieties, like Jonathan, Delicious, and Ben Davis produce unusually large quantities of viable pollen.

There are some varieties which are partly self-fruitful when planted in large blocks, including Jonathan, Maiden Blush, Rome Beauty, Oldenburg, Wealthy, Yellow Transparent, Golden Delicious, Yellow Newtown, Grimes Golden, York Imperial, and others. However, it is now generally agreed by horticulturists that even with these varieties, cross-pollination should always be provided in commercial plantings.

Blooming period for different varieties must overlap. In order for cross-pollination to take place, it is obviously important that the varieties bloom at approximately the same time. Length of blooming season varies from one week to slightly more than two weeks, depending upon the variety and weather conditions. Some varieties open their blossoms relatively early in spring, such as Red Astrachan, Early Harvest, Gravenstein, Fameuse (Snow), McIntosh, Melba, Milton, Oldenburg, Ohio Nonpareil, and Wagener. The late blooming varieties are Gallia Beauty, Northern Spy, Macoun, Northwestern Greening, Rome Beauty, and York Imperial with Ralls and Ingram very late blooming. Most other commercial varieties are midseason bloomers.

If the temperature is high during the blooming period, all varieties, excepting the late ones, may bloom very close together or almost simultaneously. In some years, when a sudden hot spell at the start of blooming is followed by a protracted cold and rainy period, the time of blooming of varieties may be unduly long. In such seasons, varieties that come into full bloom rather early may be past the pollination stage before the others are ready to shed their pollen freely. Thus, cross-pollination troubles may be encountered, as for example, between the relatively early blooming Duchess of Oldenburg and the late blooming Rome Beauty. This is not likely, however, between most of the midseason and late blooming varieties.

Importance of bearing age. Some varieties, as McIntosh, come into bearing at the age of 6 to 7 years, whereas others come into bearing late at the age of about 12 years, as Northern Spy. Thus, the McIntosh may flower for six years without fruiting until the Northern Spy develops flowers. Under these conditions, it will be necessary to use a third variety such as Cortland to provide cross-pollination for the McIntosh. Ages at which commercial apple varieties come into bloom are given on page 56.

Consider alternate bearing habits. Under somewhat neglected cultural conditions, some varieties have a tendency to bear a large crop one year and a small or no crop the next. Golden Delicious and Yellow Transparent are examples. Obviously, there will be little or no source of good pollen in the "off" year from the alternate bearing variety. Under these conditions, a third variety should be employed in order to play safe. Information on the tendency of apple varieties to alternate bear light and heavy crops, is given on page 56.

Suggested planting plans. No tree should be planted further than two permanent rows (80 to 100 feet) from its pollinizing variety. Hence, a single variety can be planted in blocks of four rows, provided the pollinizing variety is planted on either flank, as shown in Figure 80. Exceptions to this rule may be made in case of varieties which are partly self-fruitful such as York Imperial, Yellow Transparent, Rome Beauty, and possibly Jonathan, although the latter may be erratic under some conditions. These varieties may be planted in blocks of six rows with the pollinizing variety on either flank.

Jonathan	J	J	J	J	J	J	J	J	J
Jonathan	J	J	J	J	J	J	J	J	J
Jonathan	J	J	J	J	J	J	J	J	J
Jonathan	J	J	J	J	J	J	J	J	J
Grimes Golden	GG	GG	GG	GG	GG	GG	GG	GG	GG
Jonathan	J	J	J	J	J	J	J	J	J
Jonathan	J	J	J	J	J	J	J	J	J
Jonathan	J	J	J	J	J	J	J	J	J
Jonathan	J	J	J	J	J	J	J	J	J
Grimes Golden	GG	GG	GG	GG	GG	GG	GG	GG	GG

Figure 80. In this planting plan no tree is more than two rows from its pollinizing variety. Both varieties have good pollen and are cross-fruitful.

If the grower desires to have the majority of his trees of one variety with as few of the pollinizing variety as possible, the planting plan shown in Figure 81 can be used. In this case, the pollinizing trees are located at every third permanent tree in every third permanent row. This has proven entirely satisfactory, providing the blooming seasons overlap, the varieties come into bearing about the same age, they are cross-fruitful, and neither variety has a tendency to bear a heavy crop one year and a light crop the next.

Delicious	D	D	D	D	D	D	D	D
Delicious	D	D	D	D	D	D	D	D
Delicious	D	J[2]	D	D	J	D	D	J
Delicious	D	D	D	D	D	D	D	D
Delicious	D	D	D	D	D	D	D	D
Delicious	D	J	D	D	J	D	D	J
Delicious	D	D	D	D	D	D	D	D
Delicious	D	D	D	D	D	D	D	D
Delicious	D	J	D	D	J	D	D	J

Figure 81. One variety is emphasized in the following planting plan, and the other is used sparingly as a pollinizer. The varieties are cross-fruitful.[1]

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[1] If this orchard were planted solidly to Delicious by mistake, every third tree in every third row could be top-worked to Jonathan. If the solid planting were McIntosh, each tree to be grafted should be top-worked to two varieties, half of the tree to one variety and half to the other, such as Cortland and Early McIntosh.

This plan is recommended for Missouri conditions by Murneek. Under conditions of Shenandoah-Cumberland region, Dr. I. C. Haut of University of Maryland points out that this arrangement of Delicious for minimum pollination conditions would be inadequate in cold wet weather during blossoming.

[2] Jonathan.

Where the pollen of one variety is of little or no value in cross-pollination, as with Stayman Winesap or Rhode Island Greening, and it is necessary to use three varieties, a suggested planting plan is shown in Figure 82.

Pollinizers	EM[1]		C[2]		C		EM		C		C		EM		C	Permanent trees
McIntosh		m		m		m		m		m		m		m		Semipermanent trees
McIntosh	M		M		M		M		M		M		M		M	
Pollinizers		em		c		c		em		c		c		em		
McIntosh	M		M		M		M		M		M		M		M	
McIntosh		m		m		m		m		m		m		m		
Rhode Island Greening	RIG		RIG		RIG		RIG		RIG		RIG		RIG		RIG	
McIntosh		m		m		m		m		m		m		m		
Rhode Island Greening	RIG		RIG		RIG		RIG		RIG		RIG		RIG		RIG	
McIntosh		m		m		m		m		m		m		m		
Pollinizers	EM		C		C		EM		C		C		EM		C	

[1] Early McIntosh.

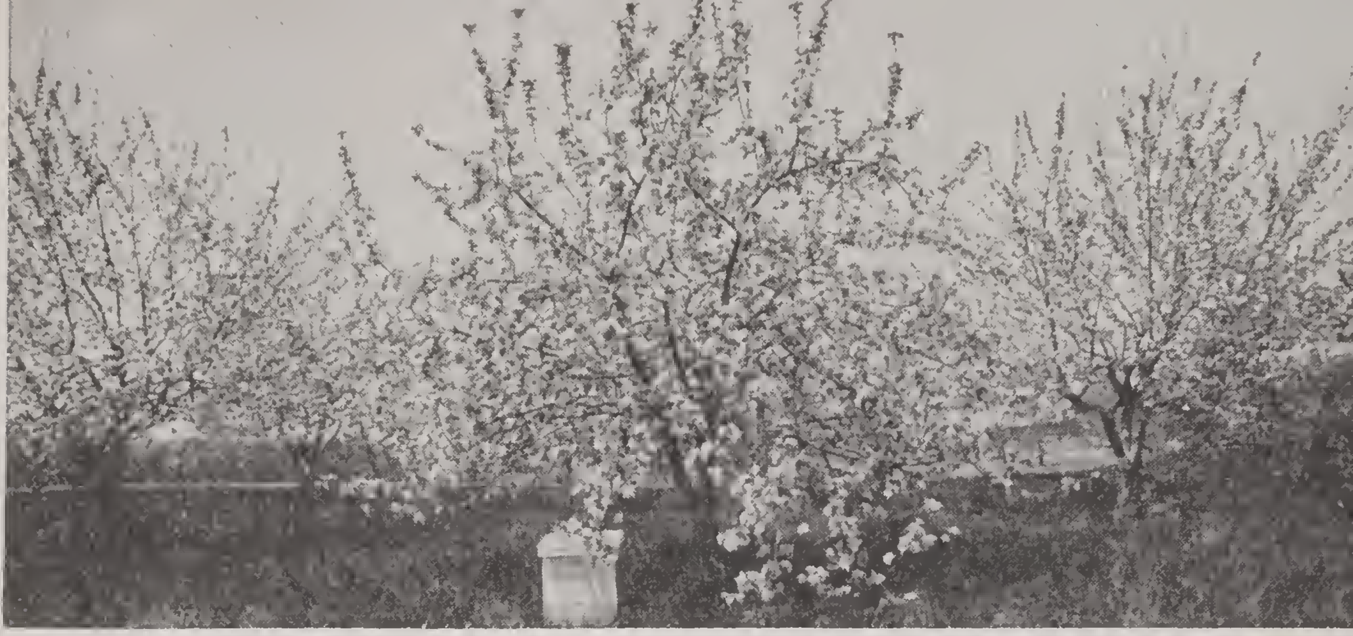
[2] Cortland.

Figure 82. An apple variety with infertile or poor pollen is used in this planting (Rhode Island Greening). Two other varieties are needed to cross-fertilize this variety and each other. McIntosh and Early McIntosh are early blooming; the other two varieties are midseason blooming. Adapted from MacDaniels and Heinicke.

Use of bees in the orchard. Due to the importance of honeybees in cross-pollination, some growers have made a habit of bringing in bees a day or so in advance of the blooming period. The hives are scattered throughout the orchard so there is one strong colony for each one or two acres (Figure 83). One hive to ten acres may be sufficient for young bearing trees. The grower sometimes owns his own bees, but attempts by growers to raise bees have usually been disappointing. It seems better for him to rent the bees from a beekeeper, due to the specialized nature of beekeeping. A medium strength colony contains 15,000 to 20,000 bees. Extra strong colonies containing eight to nine pounds of bees have been effective in pollinating over four acres of trees during good weather. During unfavorable weather, bees may travel only half a tree to two trees from the hives. The most striking results from bringing bees into the orchard will be evident in a season with only a few hours of favorable weather during bloom. It is during these seasons that apples are usually scarce and bring the higher prices.

In some localities, orchardists and beekeepers are co-operating to their mutual benefit, the orchardist furnishing the beekeeper with a favorable site for his hives in return for the benefit of the pollination. The orchardist pays for the transportation of the hives to and from the orchard, and takes special care not to spray the trees with arsenicals while the bees are still working. Bees should not be left in the orchard throughout the year; aside from being in the way, they may bother the workmen.

Top-working to provide pollinizers. Commercial growers nowadays rarely make the mistake of planting solid blocks of a single variety. When this situation arises, however, it is possible to top-work or graft every third



E. F. Phillips, Cornell University

Figure 83. The honeybee is credited with about 90 per cent of pollen transfer in orchards. One strong hive per acre scattered through the orchard at blossoming time is helpful in obtaining a commercial crop.

tree in every third row to a pollinizing variety, as shown in Figure 81. If the solid block consists of a variety with nonviable pollen, a tree next to each of the above-grafted trees can be top-worked to a third variety which is cross-fruitful with the other two.[1] Or, every third tree in every third row can be top-worked half to one variety and half to the other. These grafts will not bloom for three years. In the meantime, it is necessary to bring in bouquets of flowers in buckets or two-quart jars of water and hang the bouquets in the grafted trees. Bees should be provided in this case to insure maximum pollination. Grafts are pruned as little as possible in order that they flower earlier. It is important to provide bees in the orchard at least until the grafted trees are blooming rather heavily all over.

Hand cross-pollination. Solid blocks of Delicious and Winesap in recent years have been cross-pollinated by hand in the Pacific Northwest. In New York, this system was successfully used on large blocks of McIntosh. The total cost of applying 400 ounces of pollen to 175 acres of orchard in the West was $15.00 per acre, or 30 to 35 cents per tree (late 1930's). Theoretically, there is no need for fruit thinning with hand cross-pollination because the operator is able to decide the number of apples the tree will carry, or, about one to two fruits in every four flowering spurs. Generally, however, this method is used only as a makeshift until permanent cross-pollination can be provided.

Too much cross-pollinization. If all provisions have been made for good cross-pollination and the weather during the blooming period is quite favorable, it is probable that there will be excessive fruit set. At present, however, there is no method for obtaining a definite amount of cross-pollination and no more. It seems best to provide for more than a full commercial crop and then remove the overload by hand-thinning.

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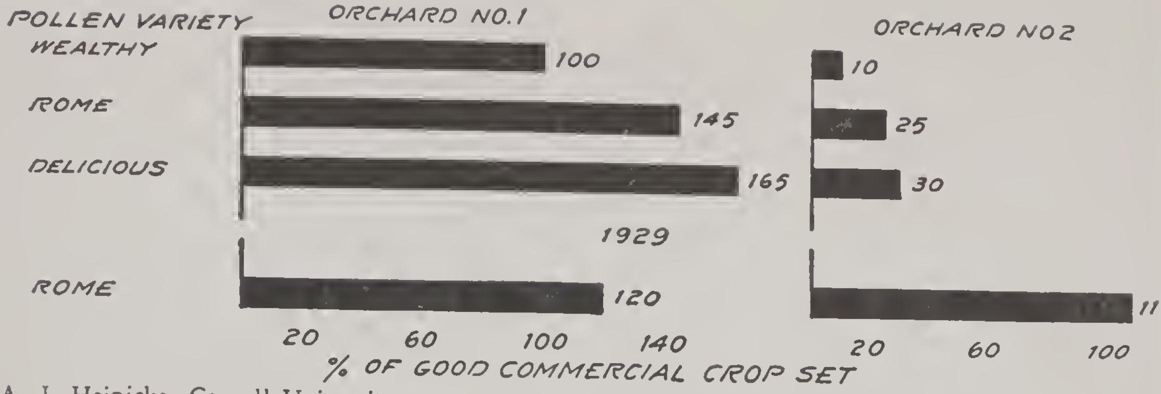
[1] If possible, use a yellow variety for top-working on a red variety, or vice versa. This enables pickers to keep the varieties separate while harvesting.



A. J. Heinicke, Cornell University

Figure 84. Heavy bloom and good pollination conditions were available in both orchards above. Orchard No. 1 had received good cultural care and was in moderately vigorous condition; orchard No. 2 had been neglected and was in weak condition. Note better crops of Northern Spy apples in orchard No. 1. Trees in both orchards were hand pollinated with pollen of Wealthy, Rome Beauty, and Delicious.

It has been the experience of some commercial growers that there are sufficient wild insects in the neighborhood of their orchards to provide adequate cross-pollination, in which case it is not necessary to bring in bees. Other growers have removed the bee hives after one or two days of good weather for bee activity. The bee hives must be removed at least to a distance of one mile from the orchard.

The effect of pollen on shape, size, and color of fruit. The shape and color of an apple are typical for the variety regardless of the source of pollen. It is true, however, that cross-pollinated fruits are often of better shape, size and color than those obtained from self-pollination. This is probably due to the fact that the cross-pollinated fruits have more seed, start growth sooner, and because of additional seed, they have more uniform shape, and better size and color at picking time. Pollen from a yellow variety, such as Golden Delicious, does not cause yellow streaks to appear on red apples, neither does the pollen of an oblong or flat apple change the shape to a round apple.

Factors affecting the set of fruit. *Nitrogen* is most frequently the limiting factor in orchards, and applications of this element two weeks or a month before bloom are usually effective in increasing the fruit set on mature bearing trees. Figure 84 shows a comparison between the fruit set on a neglected orchard low in nitrogen and one having moderate vigor under good care. *Pruning* the winter previous to an expected heavy crop is a common method of increasing the fruit set. Such a practice reduces the competition between the remaining flowers for carbohydrates, water, and nitrogen. The practice of *ringing* is resorted to only in particularly stubborn cases where the tree produces flowers with little or no set of fruit. In this case, ringing must be done not later than full bloom to affect the set of current blossoms.

Temperatures below 40° F. during bloom not only inhibit bee activity, but they hinder pollen germination. There is some germination at 40° to 50° F., but not until the temperature reaches 60° to 70° F. is pollen germination satisfactory. Optimum conditions for pollen germination and pollen tube growth are between 70° and 80° F., above which there is a decrease. Frosts just preceding or during blossoming may decrease the crop considerably. The further open a blossom is when the frost occurs, the more susceptible it is to freezing. Fully opened apple blossoms may be killed at temperatures between 25° and 28° F. Delicious is quite susceptible, followed by Stayman Winesap, Arkansas, and Winesap. Although the first blossoms to open on these varieties may be killed, the later blossoms set sufficient fruit to give full commercial crops. The blossoms of Rome Beauty and York Imperial usually withstand frosts quite satisfactorily and this may be due partly to their late-blooming habit. Other varieties more resistant to frost at blooming are Jonathan, Oldenburg, Grimes Golden, Summer Rambo, and Wealthy.

The pistil, or female organ, is usually killed first by low temperatures. If the buds are unopened, freezing injury to the pistil can be detected by cutting the bud in half; dead pistils will be brown, live pistils green. Pollen is more resistant to frosts and can remain viable at several degrees below 32°F. If the temperature hovers at 29°F. or below only for a few hours, injury may not result. The longer the period of cold, the more likely the injury.

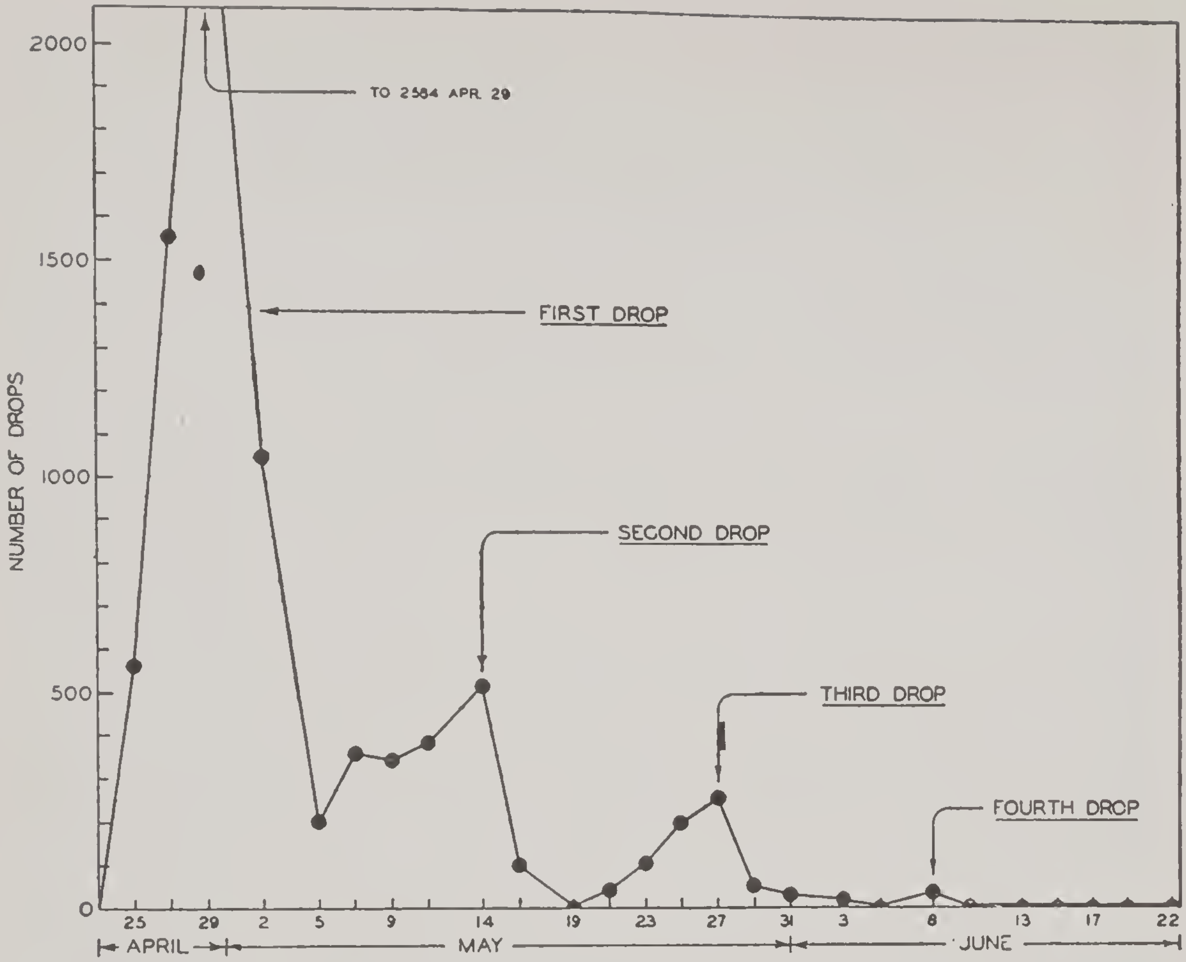
Wind may affect the set of fruit by inhibiting bee activity, desiccating the stigmas, or excessively whipping the flowers and destroying their capacity to function. High *humidity* may prevent proper release of pollen. Low humidity may dry the stigmas and reduce pollen germination. *Rainfall* also inhibits bee flight and prevents release of pollen. Intermittent rainfall with periods of sunshine during the bloom period, however, ordinarily does not adversely affect a commercial set.

APPLE DROPS

Fruit growers are familiar with the fact that though an apple tree may bloom profusely, only a relatively small percentage of the flowers will mature into fruit. Actually, only about one bloom in 20 is needed for a good commercial crop on a full-blossoming apple tree. Most of the blossoms fall soon after full bloom with smaller amounts dropping later. It is true that the various drops may be so great that the final yield is seriously reduced.

Two general drop periods are usually recognized (Figure 85), one defined as the "first drop" which begins shortly after petal fall and continues for two or three weeks. The other drop is the better known "June drop" which is more obvious to the fruit grower because the fruits have developed to a larger size. The June drop begins a few weeks after the first drop and continues for two to four weeks. In some parts of the country, it may begin in late May and be completed in June, or begin in June and be completed in July.

These drops are remarkably uniform from year to year under varied weather conditions. The behavior has been regarded by some workers as a hereditary characteristic. The quantity of fruit that drops early or late varies with the variety. Some varieties have a heavy first drop shortly after bloom with a relatively light second drop. Examples of these are Stayman Winesap,



A. E. Murneek, University of Missouri

Figure 85. Murneek describes four waves of apple drops in Missouri. Horticulturists usually lump the first and second drops into the "First Drop" and the third and fourth drops into the "June Drop." Note relative size of the first drop.

Arkansas, Rhode Island Greening, Delicious, Tompkins King, and Winesap. With other varieties, the first drop is relatively light with the later drop heavier; these varieties include Baldwin, Grimes Golden, Wealthy, Yellow Transparent, Oldenburg, and Rome Beauty.

Information is still quite incomplete as to the cause of the various apple drops. It seems to be clear, however, that most of the flowers that drop soon after full bloom do so because of the lack of pollination, or as a result of self-fertilization. It is possible to reduce the early drop, if that be desirable, by providing the right varieites for cross-pollination and by putting more bees into the orchard.

The June drop consists of apples one-half- to one-inch in diameter. Because these apples stay under the tree longer and are more conspicuous, the apple grower frequently worries more about the June drop than the more significant early drop. The cause of the comparatively late shedding of immature apples is probably due to competition among the fruits for food and water. It is not certain if the supply of nitrogen, carbohydrates, or some other indispensable substance becomes limiting first when the fruit load is excessive for the capacity of the particular tree. One relatively weak branch on a tree may release a large number of drops, whereas an adjoining more vigorous branch may shed only a few. Fruits which contain the fewest or weakest seeds are usually the first to drop. Although there does not seem to be any practical way of controlling the June drop in apples, it is probable that the maintenance of sufficient vigor and the development of healthy foliage will reduce its severity. Judicious fertilization with nitrogen and pruning may also have a helpful influence.

Review Questions

1. Distinguish between pollination and fertilization.
2. What part of the flower produces the sperms; what part bears the egg?
3. What are the agents responsible for transfer of pollen from one plant to another; which is the more important?
4. List 5 commercial apple varieties which are good pollinizers and 5 which are poor pollinizers.
5. Diagram a plan for planting a poor pollinizing variety with good pollinizing varieties so as to secure effective cross-pollination. Use varieties commonly grown in your locality.
6. What would you do to an 8-year solid block of Delicious to secure good cross-pollination? Name the variety or varieties used and practices followed subsequently.
7. Does vegetative growth slow down because of flower-bud formation, or, does flower-bud formation occur because of a slowing down of vegetative growth? Explain.
8. List environmental factors which may adversely affect pollination and set of fruit.
9. Are the "bud sports" of standard varieties generally good pollinizers for their parent varieties? Explain.
10. What is an important factor causing lopsided fruits?

Suggested Collateral Readings

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CHAPTER VII

Thinning Apple Fruits

Thinning is the removal of a part of the crop before it matures on the tree with the object of (1) increasing the marketability of the remaining fruit, and (2) preventing overbearing. Indeed, thinning may be grouped with pruning and fertilization as among the important cultural practices which tend to induce and maintain tree vigor. Horticulturists, in general, consider it sound practice to provide for a full bloom by good orchard management, and then if conditions during bloom are particularly favorable for a heavy fruit set, it becomes necessary and advisable to hand thin the excessive fruit a few weeks after bloom. Recently, certain chemical sprays have been applied during bloom in order to reduce the fruit set and thus, eliminate hand thinning. Although this method is still in the experimental stages, it shows possibilities which are discussed at the end of this chapter.

Fruiting is an exhaustive process to the tree, especially if the crop is heavy. Hence, the chief goal is to permit the tree to mature as large a crop as possible and yet conserve sufficient nutrients and carbohydrates for good shoot and spur growth, leaf development, and flower-bud formation for next year's crop. If the tree is permitted to mature an excessive crop, obviously it becomes devitalized to the point where it not only produces an inferior product, but it is increasingly suspectible to disease and low-temperature injury.

Thinning is practiced only on trees carrying a moderate to heavy crop of fruit. It accomplishes relatively more on mature trees making small annual growth, or on trees reduced in vigor with weak leaf surface than on young vigorous trees of the same variety. Response is better on light soils deficient in moisture than on heavy loams with adequate moisture. Trees growing in sod alone usually respond better to thinning than trees growing under mulch or some system of cultivation.

After years of commercial experience in thinning apples, it has become increasingly apparent that thinning is necessary on small-fruited varieties which tend to retain an overload of fruit after the June drop. These varieties include Grimes Golden, Golden Delicious, Wagener, Early McIntosh, Baldwin, and Wealthy. Although varieties such as Jonathan, McIntosh, and Stayman Winesap require relatively less thinning than the above varieties, in some seasons after a particularly heavy set, thinning is a necessity in order to increase size and quality of fruits. Delicious and its bud sports require more leaf surface per fruit than most varieties in order to attain high flavor and dessert quality; otherwise, the fruits may have a "starchy" flavor.

OBJECTS OF FRUIT THINNING

The reasons for thinning may be outlined as follows:

1. Increase yield of marketable fruit.
2. Improve size.
3. Improve color.
4. Improve eating quality.
5. Reduce limb breakage.
6. Promote tree vigor and, where early thinning is practical, to induce more regular cropping.
7. Minimize the handling and storage of low grade and cull fruit.
8. Permit more thorough spraying and dusting of fruits during late-season applications.
9. Expedite all handling operations at harvest and reduce their respective costs.

Thinning increases fruit size. Probably the most pronounced effect of thinning is an increase in size of fruit, largely as a result of allotting more leaf surface for each fruit. Experimental evidence has shown that good size and quality can be obtained when fruits of most varieties are spaced to allow about 30 to 40 average size leaves in the vicinity of each fruit. If 50 or more leaves are left per fruit, there appears to be little additional increase in size and quality of the fruit. The usual commercial practice of spacing the fruits from six to eight inches apart on the branch allows about 30 average-size leaves per fruit for most varieties.

Table 13 shows the effect on size, grade, and cash returns of spacing Winesaps from three to four inches, six to seven inches, and nine to ten inches apart on 12-year trees in Oregon. While these results are striking, they more or less exemplify the trend of results reported in other states.

Under conditions of the above experiments, the peak returns were obtained by thinning the fruit a distance of six to seven inches on the branches. At this distance there were about six boxes of fruit per tree which had 163 or less apples per box as compared with one-half box in this class from the un-

TABLE 13

EFFECT OF THINNING WINESAP FRUITS ON SIZE, GRADE, AND CASH RETURNS FROM 12-YEAR TREES IN OREGON

(Adapted from G. G. Brown)

THINNING TREATMENT	GRADE	163 FRUITS PER BOX AND LARGER		175 FRUITS PER BOX AND SMALLER		TOTAL BOXES	VALUE PER	
		Box Value	No. Boxes	Box Value	No. Boxes		Tree	Acre
No Thinning	Extra fancy	$2.00	½	$1.50	1	1½		
	Fancy	1.75	0	1.25	1½	1½		
	C. grade	1.50	0	1.00	1½	1½		
	Culls	....	..	....	...	10¼	$5.87½	$305.50
Thinned 3″ to 4″ apart	Extra fancy	2.00	2	1.50	1	3		
	Fancy	1.75	½	1.25	½	1		
	C. grade	1.50	1	1.00	2¾	3¾		
	Culls	....	..	....	...	5¼	$11.25	$585.00
Thinned 6″ to 7″ apart	Extra fancy	2.00	3½	1.50	1	4½		
	Fancy	1.75	1	1.25	½	1½		
	C. grade	1.50	1½	1.00	2½	4		
	Culls	....	...	....	...	1¾	$15.62½	$812.50
Thinned 9″ to 10″ apart	Extra fancy	2.00	3½	1.50	½	4		
	Fancy	1.75	1½	1.25	0	1½		
	C. grade	1.50	1½	1.00	2½	4		
	Culls	....	...	....	...	2	$15.12½	$786.50

thinned trees; gross returns were over twice as much for the thinned trees. Thinning a distance of nine to ten inches with Winesaps gave no advantage over six to seven inches.

Thinning is not the only factor which influences size of fruit at harvest.

1. Some apple varieties inherently produce small fruits and require more hand thinning than varieties which produce characteristically large fruits.
2. As the tree becomes older, the fruits tend to become smaller in size, as for example with Wealthy. This is because old trees set heavier crops than young trees, possibly because of the accumulation of a reproductive hormone in the older trees.
3. Fruit size is markedly reduced under drought conditions.
4. Fruits are usually larger when the trees have been pruned the winter preceding a heavy crop.
5. Vigorously vegetative growth produces larger fruit than weak growth.
6. Foliage injury by caustic sprays during the growing season may result in smaller fruit size.

Thinning increases fruit color. Fruit thinning tends to increase the amount and intensity of red overcolor and yellow undercolor of apples. The effect of thinning on red color has been shown in Table 13 where more highly colored apples (Fancy and Extra Fancy) were obtained when the fruit was spaced six inches or more. Results have shown that there is a gradual increase in over- and undercolor of apples with an increase in number of leaves to about 30 per fruit. This is important to consider for apple varieties such as Winesap which need considerable red color in order to fall in the higher grades. The general effect of thinning on color, however, is usually not as striking as its effect on size.

Thinning increases dessert quality. When a fruit is accompanied by adequate and efficient leaf surface, it is better supplied with carbohydrates and other materials which are necessary for good flavor and quality. The result is largely due to an increase in the sugar sucrose. Most apple varieties require 30 leaves per fruit for good dessert quality, except the Delicious and its bud sports which, as pointed out earlier, require about 40 leaves in order to avoid a characteristically undesirable flavor obtained at lower fruit-leaf ratios.

Thinning reduces limb breakage. A heavily loaded mature McIntosh tree may carry almost a ton of fruit. Obviously, the leverage and strain of such a crop is tremendous and much aggravated by high winds. The grower cannot afford to take chances on losing large sections of his trees by overloading. Thinning not only reduces this danger, but partially or entirely eliminates the necessity for propping. The preparation of numerous props from saplings or branches of large trees entails considerable time and labor, more than might be expected. Props, when needed, can be prepared from rough-sawed boards with the following dimensions: 1″ × 4″ × 6′ to 8′, or 1½″ × 6″ × 10′. A semicircular notch in the upper end serves to hold the branch.

Thinning reduces disease and insect injured fruits. Thinning offers an early opportunity to remove malshaped specimens and fruit injured by insects and diseases, all of which are bound to fall in the cull class in the grading operation. These fruits not only rob the better fruits of nutrients, carbohydrates, and water, but are expensive to handle during the picking and grading season. Also, spread of insects and diseases can be greatly checked by removing injured fruits which may rub against healthy fruits. Thorough spraying is difficult among unthinned groups of two and three apples.

Thinning reduces cost of handling the crop. Although there are no specific figures to demonstrate the reduction in handling costs as a result of thinning, it is obviously less expensive to handle a crop 85 per cent in the upper grades with 5 per cent culls than one 50 per cent in the upper grades with 25 per cent culls. The cost of thinning is largely counteracted by the reduction in handling costs at harvest. Also, it is cheaper to pick apples at thinning time than at harvest time, because the fruits are dropped to the ground as soon as separated from the tree.

Thinning affects yield. Experimental results of thinning on fruit yields are variable, but the majority of the experiments indicate that thinning by standard methods tends to reduce the total yield. This is more or less to be expected since the practice is designed to decrease competition between fruits so that the remaining fruits will derive the benefit of increased water and food materials. The effect on yield seems to depend entirely upon the extent of reduction of the crop by thinning. Apples attaining a diameter of two and one-half inches are considered of marketable size. One must be careful, however, not to overthin and produce oversized fruits which are often inferior in eating and storage qualities.

Interrelation of pruning and nitrogen fertilizers. Pruning and thinning are interdependent. If a tree has been invigorated by pruning during the previous winter season, there will be less need for fruit thinning the following summer. On the other hand, if there has been light or no pruning during the previous season, there may be a greater need for fruit thinning. It seems desirable not to try to eliminate thinning by heavy pruning. On the contrary, pruning should be kept to a minimum consistent with its favorable effects, and the excess fruits removed by hand thinning.

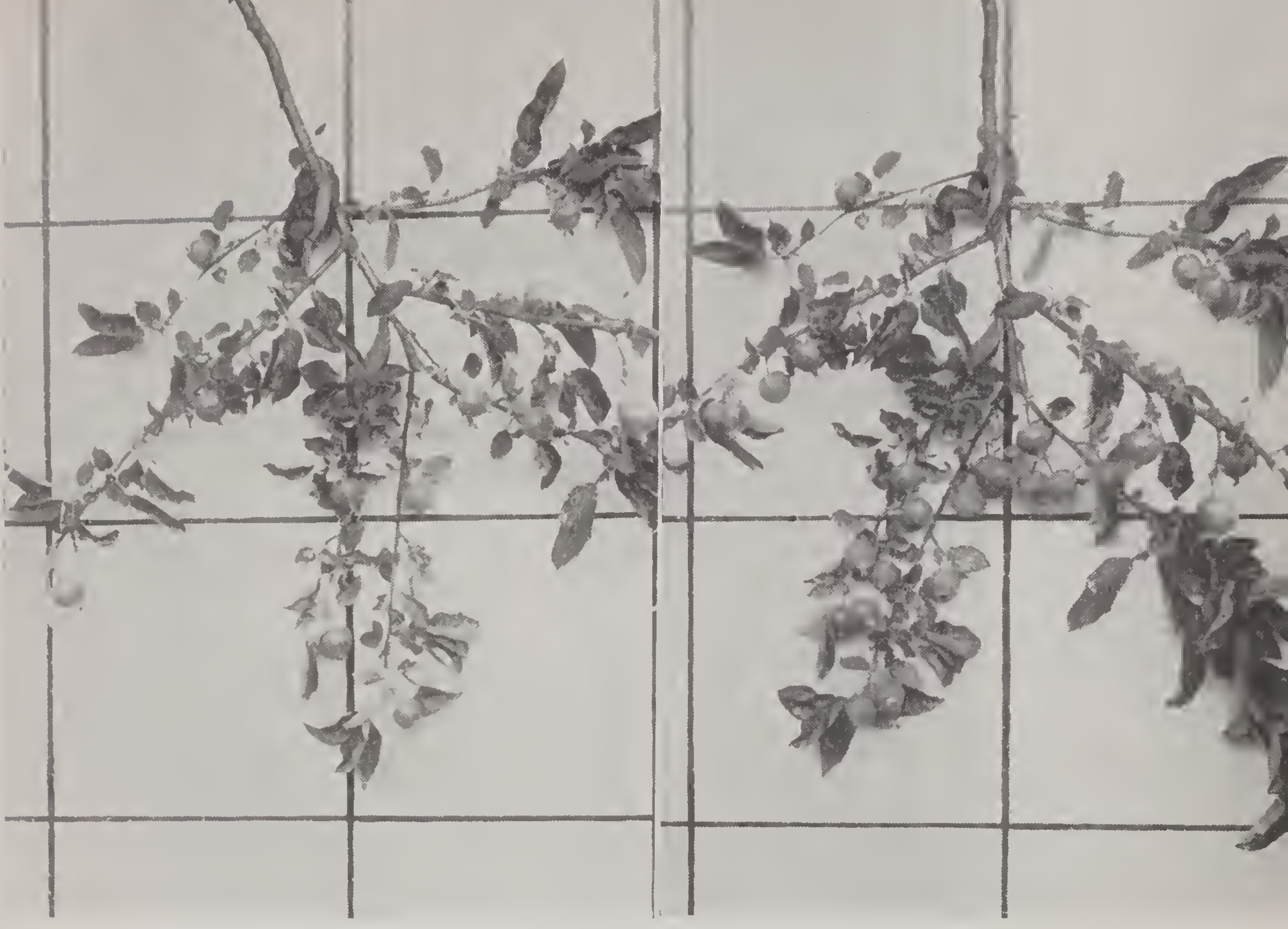
It has been pointed out in the chapter on soil management that excessive application of nitrogen fertilizers results in poor fruit color. Fruit color can be more easily controlled by regulating the nitrogen fertilizer than by thinning or pruning. Therefore, from a practical standpoint, it is important to carefully regulate nitrogen so that the color of the fruit is not adversely affected.

TIME TO THIN

Magness and his co-workers have clearly shown that the sooner the thinning is completed (20 to 25 days after full bloom), the more favorable the effect on fruit size at harvest and on fruit-bud formation for next year's crop. However, early hand thinning is tedious and expensive, and is recommended only to correct bad cases of biennial bearing on relatively frost free sites. As pointed out in an earlier chapter, spring frosts can readily initiate alternate bearing by destroying the crop in any one year. Where early thinning is practiced, the greater expense involved actually should not be confined to one year, but spread over several years if the practice initiates regular cropping.

With varieties which ripen in fall and winter, such as McIntosh and Delicious, the usual commercial practice is to wait until immediately after the June drop before thinning. On the other hand, with summer varieties which ripen two or three months earlier, such as Yellow Transparent, Duchess, and Wealthy, better response is obtained if thinning is done before the June drop. Thinning at this time may greatly reduce the June drop. Some growers with the Yellow Transparent variety carefully select and thin fruit which ripens earliest, placing these small-sized somewhat immature fruits on the market for sauce. The removal of these fruits enhances the size of the remaining fruits which are picked several days later.

Method of thinning. Remove the apples which are inferior in size, malformed, disease and insect injured, giving preference to those apples which are better exposed to light conditions. It has been pointed out that one should leave about 30 leaves, or between 100 to 125 square inches of leaf surface

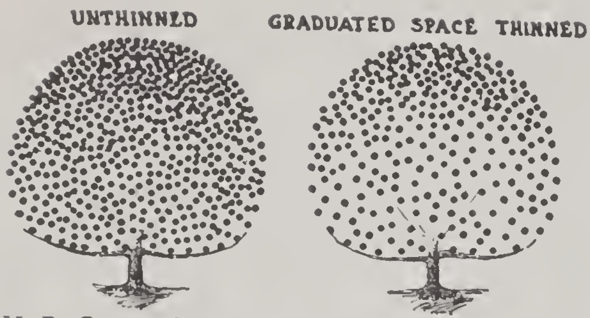


F. S. Howlett. Ohio Agr. Exp. Sta.

Figure 86. McIntosh branch before (left) and after (right) fruit thinning by "uniform-space" system, leaving the apples about six to eight inches apart. Each square is twelve inches.

per fruit. In order that the thinners might better visualize this amount of leaf surface, the foreman can draw a ten-inch square on paper, or lay a group of 30 average-size leaves on white paper for study. Naturally, at first the thinners will need to go slowly in estimating this leaf-fruit ratio, but with a little practice it is not so difficult as it may sound. Since about a six- to eight-inch spacing between fruits (Figure 86) allots approximately 30 leaves per fruit, the operator can bear in mind this spacing as well as the fruit-leaf ratio index in the thinning process. A reduction of fruits to one per spur is usually sufficient for such varieties as Rome Beauty, Turley, Stayman Winesap, Delicious, Rhode Island Greening, and McIntosh, under eastern conditions. However, all apples on some spurs may need to be removed to attain proper spacing on heavy-setting varieties such as Wagener, Wealthy, York Imperial, Oldenburg, Grimes Golden, Winter Banana, Golden Delicious, Yellow Transparent, and Baldwin. Usually, the center apple of a cluster is the larger and best apple to retain.

While thinning, another point should be considered. Leaves exposed near the outside and top of the tree are definitely more efficient in food manufacture than those which are shaded near the inside and center portions of the tree. The Michigan Agricultural Experiment Station has taken this factor into account when they recommend what is known as the "graduated space" method of fruit thinning. It is more or less a modification of the



H. P. Gaston, Michigan Agr. Exp. Sta.

Figure 87. The "graduated space" system of fruit thinning is recommended in Michigan. Fruits at the periphery and top of the tree on the thicker wood with better light exposure are allowed to hang more closely; fruit is thinned more heavily on the weaker wood of the inner portion of the tree.

standard "uniform space" system in which the fruits are spaced, for example, six to eight inches apart uniformly over the tree. As shown in Figure 87, with the "graduated space" system of thinning, more fruits are left near the periphery and top of the tree on wood which has greater thickness, has heavier leaf surface, and is well exposed to light. Near the center of the tree where the leaves are fewer and usually less efficient, and the fruit tends to be poorly colored, the apples are spaced much wider apart with more leaf surface per fruit. Somewhat more fruits are left on the tree by the "graduated space" system of thinning than with the "uniform space" system. The total returns for 39 experimental trees in each case were unthinned—$324.10, "uniform-space" thinned—$345.80, and "graduated-space" thinned—$400.37.

In practice, the well-informed grower will no doubt use more than one method of thinning in a judicious combination best suited to his particular variety and tree-vigor conditions.

Fruit thinning is largely done by hand, using both hands, because it is 10 to 50 per cent more rapid than with special thinning shears held in one hand. Thinning shears are used only on varieties having short stems and those which tend to set in clusters. It is sometimes difficult to thin such varieties by hand without injury to the spurs. Care is needed with shears not to clip off leaves. Thin first the heavily loaded trees of varieties which ripen earliest in the season. Thin from top to bottom, first shaking the branches lightly in order to dislodge fruits which are likely to drop of their own accord. Grasp the stem of the apple between the thumb and forefinger and push it off with the second and third fingers. Place the strain on the stem rather than on the spur. Every effort should be made to spare the spurs. With a little training and supervision, thinning can be done by women and high school boys and girls, perhaps more efficiently and economically than by "stiff-fingered" men accustomed to heavy work (Figure 88).

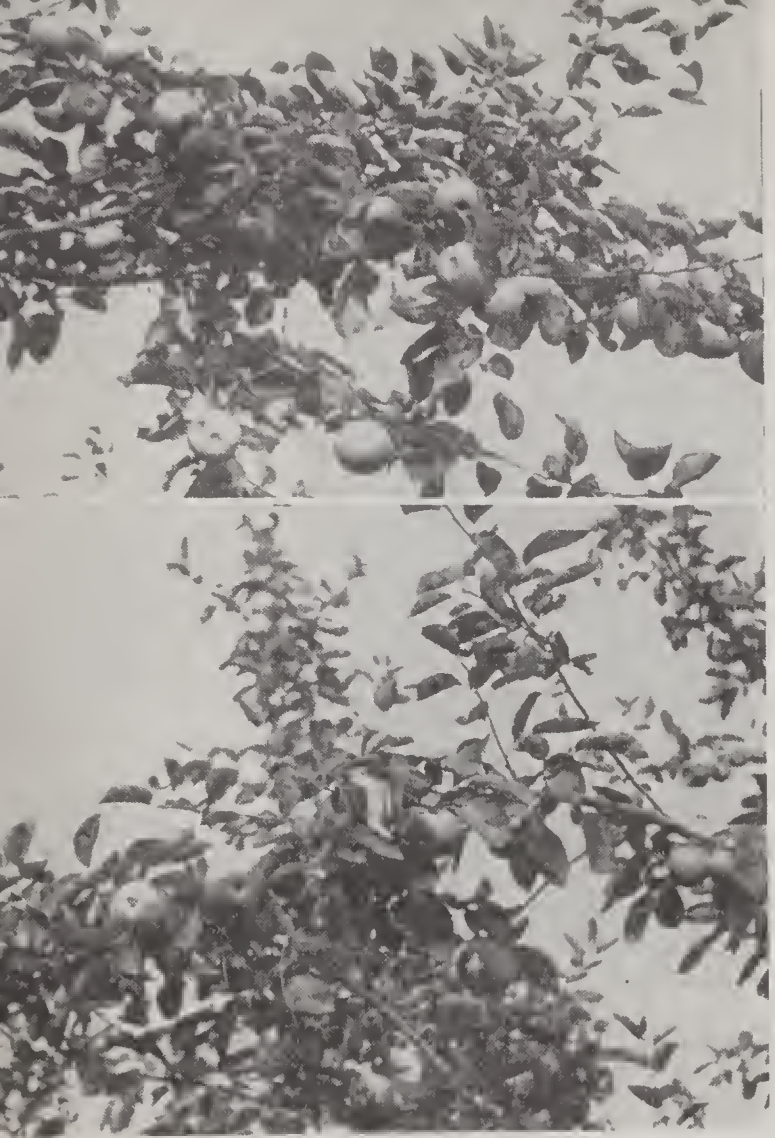
Cost of thinning. Thinning costs depend upon the speed of the worker, the hourly wage rate, the fruit load, and the size and shape of the tree. The number of fruits removed from a tree by a single workman may vary from 400 to 1500 per hour, depending upon the previously mentioned factors. In a thinning experiment at the Ohio Experiment Station over a three-year period on 30-year-old trees it was necessary to remove an average of 2115 apples from Jonathan trees and 2556 from Grimes Golden.

Very tall trees require almost twice the time to thin as low trees. It takes one person about two or three hours to thin an average-size mature tree, and about one-half to one hour to thin a tree coming into commercial production. Thinning costs actually are almost negligible because the apples must be picked at some time. Handling costs of culls and low-grade fruit at harvest are greatly reduced because the thinned apples are immediately discarded by dropping them to the ground.

Figure 88. High school boys and girls, specially selected, are often used in thinning fruit. A foreman in charge of a group of 10 to 20 children checks the work, keeps time, and moves ladders for the girls and small children.

Blossom thinning with certain chemical sprays. It has been emphasized that the earlier the thinning, the more favorable the effect on fruit size, fruit-bud formation, and regular bearing. Possibly the most simple and economical approach to the thinning and biennial bearing problems is the application of blossom-thinning spray during the bloom period, which is either sufficiently caustic or physiologically active to reduce most of the fruit set, but causes as little injury to the foliage as possible. Tar oils, cresylic acid, and di-nitro oils have been used with varied degrees of success as toxic sprays. The results of Hoffman at Cornell University are of interest. Over a four-year period he effectively used the sodium salt of di-nitro creosole (Elgetol) at a concentration of 0.1 to 0.2 per cent. It was found necessary to vary the concentration with the variety and vigor of the tree. One quart per hundred gallons (0.2 per cent) was sufficient on vigorous Wealthy trees, one and one-half pints per 100 gallons on moderately vigorous trees, and one pint per 100 gallons on somewhat weak trees.

Of the five flowers in an apple blossom, the center blossom always opens first, one or more days in advance of the side flowers, depending upon temperature. The spray is thoroughly applied immediately after the center flower in the cluster has been open for about a day, at a time when the side flowers are opening. Thus, essential parts (stigmas and pollen) of the side flowers are killed by the spray, but the fruit set of the center flower, which has been open long enough for pollination and fertilization, is not affected. Double and triple fruits on a spur are thus reduced. Flowers on weak spurs near the center of the trees may be killed entirely, while only the center blossoms on the vigorous spurs set fruit. Usually, this is sufficient for a commercial crop with such varieties as Wealthy, Baldwin, Rome Beauty,



M. B. Hoffman, Cornell University

Figure 89. Early McIntosh thinned by a chemical spray at blossoming. (Top) Not thinned. At harvest the fruit averaged 373 to the box, with prevailing size of two inches. (Bottom) Thinned with bloom spray, one pint of toxicant to 100 gallons of water. At harvest the fruit averaged 199 to the box, with prevailing size of two and one-half inches.

McIntosh and Stayman Winesap. The results of this type of blossom thinning are shown in Figure 89 for the Early McIntosh. Such alternate bearing varieties as Early McIntosh and Wealthy have produced good crops in three or four successive years of treatment with these sprays.

Some spray injury has resulted on foliage present at the time of application, but in these tests as well as in several large blocks sprayed by growers, biennial trees were induced to bear second and third crops in consecutive years. This seems to indicate that the foliage injury caused at bloom time by the spray is not as harmful as the reduction in leaf growth which results from excessive setting of fruit.

Additional experimental evidence is needed to establish the best concentration for different varieties of varied vigor. For this reason, it would be well for the grower to proceed with caution under the recommendations of the local state horticulturists.

In addition to the above results, evidence is accumulating which indicates that certain of the hormones (naphaleneacetic acid and its salts) may also prove promising for spray-thinning of fruit. These chemicals are not caustic or toxic but are physiologically active, and in this way cause a certain per cent of the fruit to shed. The grower should also keep in close touch with experiment stations regarding these developments.

Review Questions

1. Define fruit thinning.
2. List 7 advantages of thinning fruit.
3. What appears to be the best time for thinning annual bearing trees of fall or winter varieties?
4. What is meant by the following methods of thinning: "graduated space,"

"uniform space," and "leaf-fruit ratio"? Which method or combination of methods would you recommend?

5. What are the advantages of thinning blossoms with certain chemical sprays as compared with hand thinning fruit after the June drop? What are the disadvantages of these chemical sprays at blossoming?
6. How should thinning, nitrogen fertilization, and pruning be interrelated to attain the best size and quality of fruit?
7. Briefly give instructions to a workman on how to thin apples on a mature tree.

Suggested Collateral Readings

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Childs, Leroy, and G. G. Brown. Tar oil spray as an agent in changing the alternate bearing habit on the Newtown apple. Thirty-fourth Annual Report of the Oreg. State Hort. Society, 21–34. 1942.

Ellenwood, C. W. and F. S. Howlett. Apple thinning with special reference to Grimes Golden and Jonathan. Ohio Agr. Exp. Sta. Bull. 508. 1932.

Gaston, H. P. and G. L. Ricks. The "graduated space" method of thinning apples. Mich. Agr. Exp. Sta. Special Bull. 281. 1937.

Gourley, J. H. and F. S. Howlett. Modern fruit production. Chapter XI, Macmillan Co., New York. 1941.

Harley, C. P., J. R. Magness, M. P. Masure, L. A. Fletcher, and E. S. Degman. Investigations on the cause and control of biennial bearing of apple trees. U. S. Dept. of Agr. Tech. Bull. 792. March, 1942.

CHAPTER VIII

Grafting and Budding Apple Trees[1]

Every fruit grower should develop a technique in grafting. Sooner or later he may desire or be forced to change some trees in the orchard to another variety. There are several reasons for such a change:

1. The market demand for certain varieties may shift, leaving the grower with an orchard of trees bearing fruit which cannot be sold advantageously.
2. Some varieties, such as Grimes Golden, may need to be double-worked on hardy trunks and this may necessitate grafting the young trees in the orchard.
3. The varieties planted may not cross-pollinate properly and certain new varieties with effective pollen must be grafted on scattered trees.
4. Although trees have been state-inspected in the nursery for trueness to name, it is not uncommon for jobbers and dealers to lose and jumble the labels on bundled trees; hence, undesired varieties may be planted which will need to be grafted to another variety later.
5. The grower, himself, may make a mistake and order varieties which later prove undesirable.

A knowledge of grafting technique may be needed, also, for repairing bark damage which is not uncommon in most orchards. Bark damage may be caused by freezing temperatures, cultivating tools, canker diseases, or by mice and rabbits chewing away the bark.

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[1] Information in this chapter is adapted to lecture-demonstration and laboratory combined during the laboratory period. The techniques also can be applied to pear and quince.

DEFINITION OF TERMS

The meaning of frequently used grafting terms should be clearly understood at the outset in order to make later reading clear.

Stock is the root, tree, or portion of a tree into which the graft is set.

Cion (also scion) is the bud or piece of a twig which is grafted into the stock. From it grows a branch or an entire tree-top which bears the desired variety of fruit.

Interstock or intermediate stock is a piece of trunk or lower framework of a tree introduced between the stock below and the cion variety above. It is used in this position because it is better than the cion variety from the standpoint of vigor, hardiness, framework forming ability, and for its disease resistance.

Cambium layer is a single layer of living cells which lies between the bark and the sapwood. It is constantly dividing during the growing season, forming new cells; cells produced on the inside form sapwood and those on the outside form the inner bark. The cambium is responsible for increase in diameter of all tree growth and for most callus formation. It is the most essential tissue, and its preservation is highly important for continued growth. If bark is peeled back in spring, the slippery pastelike substance on the sapwood and bark consists largely of cambium-like cells which make up the cambium region.

Bud stick is growth made during the current season at the ends of branches from which buds are removed for bud grafting. From each bud may grow a branch or an entire treetop of the desired variety.

Top-working is a form of grafting by which the top of a tree is changed from one cion variety to another.

Double-working is a form of grafting in which an interstock is introduced between the root and the top by successive budding or grafting operations. Hence, double-worked trees consist of stock, interstock, and cion variety, each of which has special characteristics which make for a better and longer-lived tree.

Bridge-grafting is a form of grafting where damaged bark is bridged with wood which is grafted into the tree above and below the injury.

SHOULD YOU GRAFT?

In the long run, is it cheaper to replace the tree or to perform the grafting operations? After surveying many top-worked bearing trees in Michigan, investigators found that there were as many failures or near failures as successes. The same is often true of trees completely or excessively girdled where numerous long cions will be needed. Usually, the younger and more vigorous the tree, the better will be the chance for successful recovery without seriously delaying the bearing life of the tree. Young trees of diameters less than two inches make excellent recovery if cut off below the girdled area and (*a*) cleft-grafted, or (*b*) allowed to send up a new trunk, provided it arises from wood of the named variety.

It usually takes about five to ten years for a mature tree to recover to normal and expected production after a major grafting operation. If a tree has been girdled for a full growing season or more, its chances for satisfactory recovery after bridge-grafting are slim. Certainly, trees which have been completely top-worked never catch up with the total lapsed production that a bearing tree would have given if its limbs had not been cut back for grafting. The question might be asked, "Will the new variety after five to ten years give more net profit and satisfaction to the owner than could the old variety; and with girdled trees, is the injured tree worth the repair cost?" Although bridge-grafting is relatively time consuming, when balanced against the actual future value of a good tree, the cost is generally very small. With girdled trees, it is always well to carefully examine the depth of injury to the bark. If the sapwood is not exposed, the cambium is probably still alive, and painting with grafting wax or water asphalt, or mounding with soil will often suffice until the bark heals and thickens.

WHEN TO GRAFT

The best time for most grafting is when the buds are beginning to swell in the spring. Where it is necessary to split the wood before inserting the cion, as in cleft-grafting, this work should be done just before the bark begins to slip. If the bark is slipping readily, the wood may split along one line and the bark along another, making proper placement of the cion difficult. Cleft- and whip-grafting can be performed with dormant cion wood while the stock is dormant and as late as blossoming or later, but the latter is considered late for best results. Under Ohio conditions, the highest percentage of successful grafts were experimentally made in May, although grafts made in April, June, and July were almost as successful. Cions for the late grafting were kept dormant in cold storage until ready for use. Bridge-grafting can best be done after growth starts when the bark is slipping readily. It is difficult to bridge-graft early before the bark slips.

SELECTION AND STORAGE OF CION WOOD

Sometime during the dormant season, the grower should make a row by row inspection of his trees to record the location, variety, and amount of grafting needed. Thence, the necessary cion wood can be collected during the pruning operation. Some growers consider it a wise practice to regularly store cion wood each year for emergency jobs discovered after growth starts in spring.

Cion wood should consist of shoot growth made during the previous season. This can easily be distinguished by starting at the tip of the branch and proceeding backward to the first ring of bud scale scars which encircles the twig. This ring denotes the point where growth started the previous season; also, older wood back of it is of a different shade in color. The percentage of success with cion wood older than 1 year is usually low. Good cion wood has the following qualifications: (1) growth of one to two feet during the previous season; (2) about as thick as a lead pencil (water sprouts are satisfactory, but tips should be rejected because of immaturity; water sprouts usually remain dormant longer in spring); (3) having large plump mature buds devoid of insect eggs and disease injury; (4) no discoloration of pith due to cold injury; and (5) absolutely dormant.

If a cion stick is divided into four parts, the center two parts are the best for grafting because the buds in this area are large and healthy and the wood is well supplied with stored food. The tip buds are often immature, winter injured, or may have flower buds while buds near the base of the cion are small and weak.

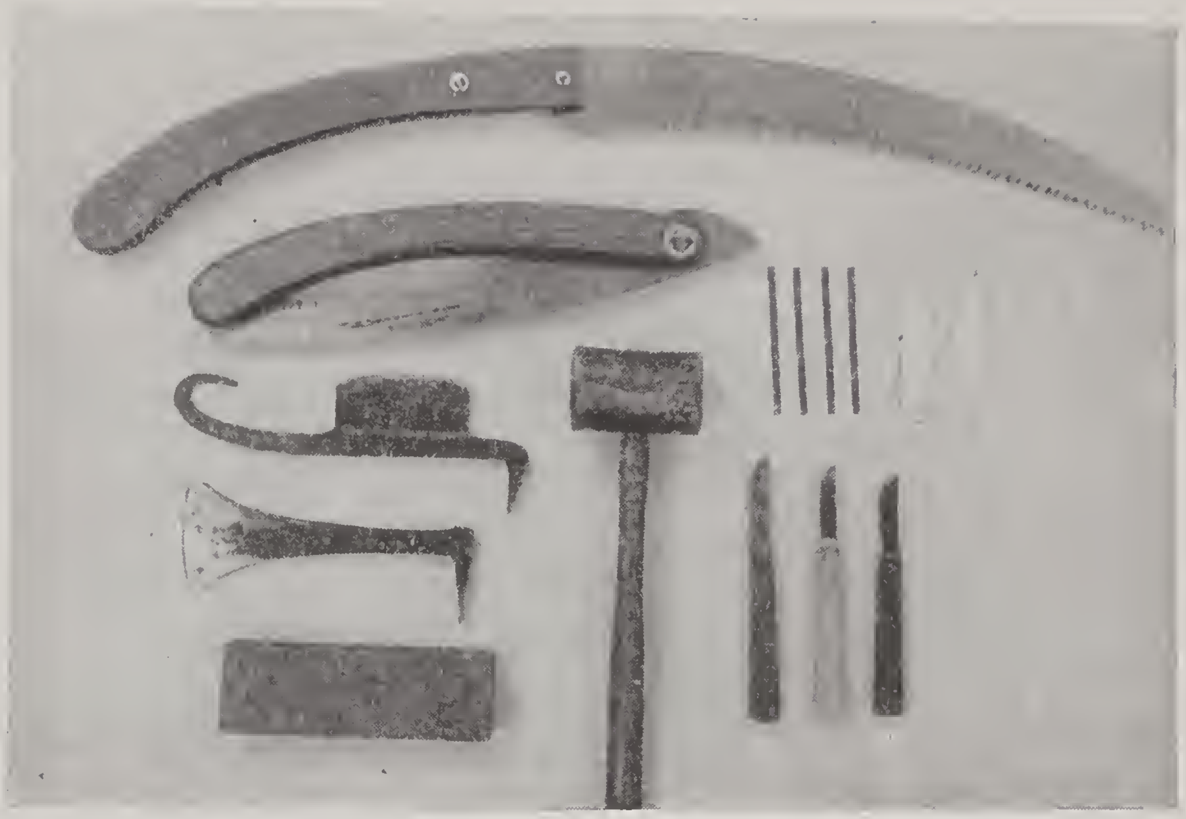
Proper storage of cion wood is extremely important. It must be kept continually cool and moist, but not wet. This can be done by wrapping the cions in cloth or heavy paper and burying them horizontally two feet deep in a well-drained spot, preferably on the north side of a building. Cion wood can be kept in common or cold storages in damp sawdust or peat moss, but it should be examined frequently and redampened if necessary. If cion wood dries or becomes too wet, its chances for growth are poor.

If the cion wood has been exhausted during grafting and more is needed, sometimes it is possible to obtain additional wood from dormant nursery trees in storage or from nearby nursery houses. Also, water sprouts in mature trees or shoots from young trees in the orchard may be a source since they start growth several days after the outer wood on mature trees. The further the buds have pushed on prospective cion wood in the spring, the less likely such wood will succeed in a graft. Cion wood with swollen buds should be used only in a limited way in exceptional cases and then covered with melted paraffin and shaded with paper bags.

GRAFTING SUPPLIES AND EQUIPMENT

Equipment needed for orchard grafting is shown in Figure 90. Most of the tools can be purchased from the local hardware stores or nursery supply companies. Grafting chisels can be made by local blacksmiths; a hammer can be used in place of a wooden mallet. Number 18 cotton string, nurserymen's tape, or raffia can be substituted for the rubber strips, but the latter are superior because they maintain an even pressure, expanding with the growth of the stock. Regardless of what is used, tension should be released by slitting the wrap about three weeks after the union is made. A modified carpenter's apron is convenient for holding the equipment and cions while grafting.

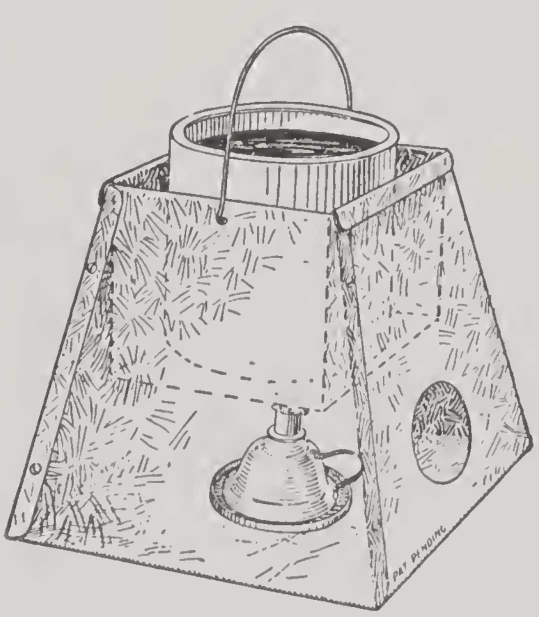
A melter, as shown in Figure 91, can be bought commercially or constructed at home. A small tapering bucket suspended in a slightly larger straight-sided bucket with holes in the side for ventilation, and an alcohol



W. P. Duruz, Oregon Agr. Exp. Sta.

Figure 90. Tools for orchard grafting are shown above. Two types of saws (workers may prefer saws with finer teeth); two types of steel grafting wedges; a coarse-fine whetstone; wood mallet; rubber strips (No. 18 paraffined cotton string, raffia, or nurserymen's tape may be used instead, depending upon graft); variety labels; one grafting knife; and two budding knives are shown.

burner in the bottom is simple to construct. The melter should be as light as possible and manueverable among limbs. A brush one-inch wide is best with a nail hook driven in the side so that it can be suspended on the side of the wax bucket. If the brush rests on the bottom of the bucket, heat from the burner will dissolve the glue and cause the fibers to fall apart.



H. A. Cardinell, Michigan Agr. Exp. Sta.

Figure 91. One of several types of commercial wax heaters with alcohol burner.

Many types of grafting waxes have been used. The ideal grafting wax should have the following qualifications: (1) exclude air and fungi and retain moisture in the wood; (2) is not toxic to tender tissue; (3) does not crack in cold weather; (4) does not melt in hot weather; (5) semipermanent; (6) is somewhat elastic to accommodate differences in growth rate of stock and cion; (7) has sufficient body during application to fill cracks; (8) relatively cheap; and (9) easy to handle. The best waxes do not entirely meet these qualifications, but several meet them well enough for practical purposes.

Waxes, or substances applied with a brush are recommended over those applied by hand. Paraffin, alone, has been generally unsatisfactory because of a tendency to crack under some weather conditions. The following formula for a brush wax has proven satisfactory: five pounds resin, one pound beeswax, one-half pound lampblack or powdered (not ground) charcoal; and one-fourth pint raw linseed oil. If grafting is done early and subsequent cold weather is expected, the proportion of linseed oil may be increased, whereas if the grafting is done late, the proportion of resin may be increased. Procedure for making the wax is (1) melt the resin, (2) add beeswax and melt, (3) add linseed oil, (4) remove heat, and (5) stir in lampblack little by little—exercise caution because the mixture is inflammable. The lampblack prevents the wax from stringing out in long threads while using; also, the black color absorbs sun rays which merge minute cracks formed during cold weather. Considerable wax can be prepared in advance, cooled in blocks, and chips melted and used as needed. Apply the wax when warm; hot wax may kill tender buds and tissues.

Asphalt water emulsions are highly satisfactory for coating grafts, and they can be purchased on the market at a reasonable price. They are applied cold with a brush. They adhere to fresh wounds and show little or no tendency to crack with temperature variations. The emulsion can be thinned to paint consistency by adding alcohol or water. If the compound is used or stored at temperatures below 40° F., radiator-type ethyl or grain alcohol should be stirred into the emulsion at room temperature. Otherwise, the emulsion may break down. In addition, about an inch of alcohol should be poured on top of the emulsion before tightly sealing in a can for storage. One must be certain that these emulsions are pure and do not contain chemicals which kill or dwarf the tissue. Two brands, "Flintkote Static" and "Foster's I.B.M." gave good results in Michigan.

TOP-WORKING

As indicated earlier, the primary reason for top-working a tree is to change the variety. For the change to be successful, (1) the graft union between stock and cion must be sound, (2) big limbs must not be exposed to sunscald during the process, (3) the new variety must be compatible with the stock, and (4) the limbs to be grafted must be carefully selected.

Limbs properly selected for top-working on a mature apple tree should be (1) from two to three inches in diameter, (2) not heavily shaded or exposed to excessive sunlight, and (3) located in prominent position and well spaced around the tree (grafting insignificant limbs is a waste of labor and materials). The limbs should be grafted relatively low or back into the tree.

Top-working of trees older than 20 years is of doubtful value, because the best wood for grafting is near the outside and top of the tree, making the job difficult and expensive to perform. Also, there is too much opportunity for shoots and limbs of the undesired variety arising below the grafts.

Special care should be taken to avoid unduly exposing large limbs to sunscald which may lead to injury by flat-headed borers and subsequent entrance of wood-destroying fungi. Danger from sunscald can be reduced by top-working the northeast half of the tree the first year. While these grafts are becoming established, foliage on the southwest side will protect the exposed stubs from sunscald. Also, in the meantime water sprouts will develop on the stubs and give them protection the following year. The remaining southwest half of the tree is then top-worked the second year and these exposed stubs usually escape sunscald because they run more or less parallel to the hottest rays of the sun between two and three o'clock in the afternoon.

It is best for the amateurs to follow the two-year plan of top-working a tree. It is true, however, that experienced grafters can spot-graft in key positions the first year so that no additional grafting is necessary. Subsequent pruning in such a case should encourage the grafted limbs to assume the main framework of the tree, while the ungrafted limbs are pruned heavily, dwarfed, and eventually removed.

Apple varieties in general can be successfully intergrafted with each other, but it is wise to use varieties of about equal inherent vigor. For example, a large-growing variety may best be top-worked on an equally vigorous variety, as McIntosh on Wolf River. The following varieties are listed[1] according to inherent vigor:

Vigorous

Arkansas
Baldwin
Benoni
Black Gilliflower
Boiken
Cortland
Delicious
Fallawater
Fameuse (Snow)
Gravenstein
Hibernal
Hubbardston
Lowland Raspberry
Maiden Blush
McIntosh
Northern Spy
Northwestern Greening
Pewaukee
Red Astrachan
Red June
Rhode Island Greening
Stark
Tolman Sweet
Tompkins King
Twenty Ounce
Winter Banana
Wolf River
Yellow Bellflower
York Imperial

Medium Vigor

Ben Davis
Chenango
Duchess
Early Strawberry
Golden Delicious
Grimes Golden
Jonathan
King David
Mann
Opalescent
Ortley
Red Canada
Roxbury Russet
Stayman Winesap
Winesap
Yellow Newtown
Yellow Transparent

Relatively Small

Mother
Rome Beauty
Wagener
Wealthy
Williams

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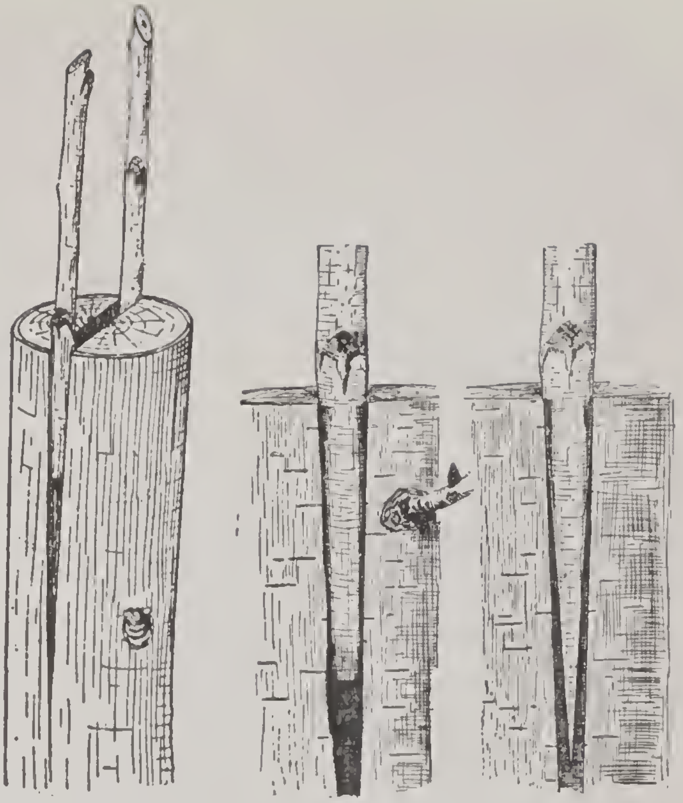
[1] Compiled from Hedrick, U. P. Systematic pomology. Macmillan Co., New York. 1925.

Cleft-grafting. The cleft-graft is made by inserting a cion into the split stock, as shown in Figure 92. Limbs selected for cleft-grafting should have the following qualifications: (1) From one to two inches in diameter; limbs smaller than one inch in diameter should be firmly wrapped with string or tape for a few weeks to assure a strong union, (2) wood six inches below the cross cut must be straight-grained and free from large knots or scars, (3) accessible from the ground if possible, and (4) more or less upright; cions in horizontal stubs tend to grow sharply upward at right angles, forming an undesirable scaffold limb.

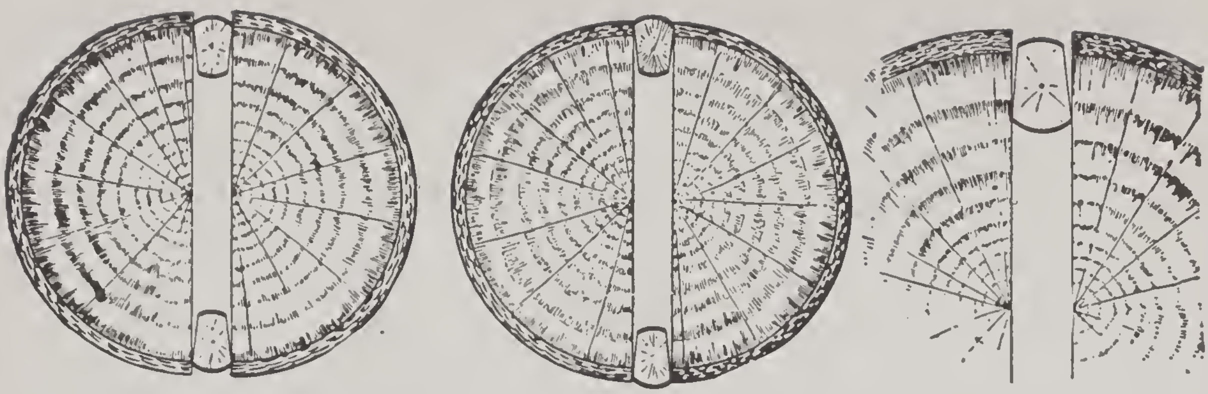


H. A. Cardinell, Michigan Exp. Sta.

Figure 92. (Left) Here is a cleft-graft complete except for waxing. Note the position of the cion buds, number of buds, and the type of cuts. Split in stock was made with grafting chisel and then held open by a wedge on back of chisel. (Middle) The cion is correctly made and placed. Note the blunt end and close contact of cambiums of stock and cion. (Right) This shows the cion improperly cut; it should not be beveled to a point; cambium contact is poor and cions may rock with the wind.

The cut across the stock should be square, not sloping. Fine-toothed saws make a smoother cut and expose the cambium zone better. Short cions with two or three buds are less likely to be knocked out by birds or wind as compared with the longer cions. Cions the size of a lead pencil with plump vigorous buds contain adequate food materials and water. Discard terminal portions of cion shoots because they may contain flower buds. Prepare the base of the cion with two sloping cuts, starting at or slightly below the level of the lowest buds (Figure 92). This appears to be of value because the food stored around the bud is much greater than between buds and, therefore, is thought to enhance union quickly enough to preserve the cion until internodal cion bark slowly unites. Do not bring the wedge to a point. The inside of the wedge should be thinner than the outside. This insures closer contact of the cambiums of the stock and cion. The top of the cion should be cut about one-quarter inch above a bud to reduce likelihood of the bud drying. Cion cuts should be straight and smooth with no wave. After a little experience, one stroke with a sharp knife makes the best bevel.

The stock stub is split across the center, using a chisel and a mallet. A four- to six-inch split is adequate The split is held open by the wedge on the back of the chisel, or with a screw driver if such a wedge is not available. Two cions are carefully inserted, making sure that the cambium of the cion and



H. A. Cardinell, Michigan Exp. Sta.

Figure 93. Reasons why some grafts fail. (Left) Cleft-graft properly made and properly set with cambiums of stock and cions of perfect contact. (Middle) This shows the failure of cambium contact between stock and cion; the cions are set out too far toward the outside of the stock. (Right) This shows the failure of cambium contact because of undue thickness of inner side of cion.

the cambium of the stock come in close contact. One must bear in mind that the thickness of the bark is much greater on the stock than on the cion (Figure 93). Buds must be upright. Contact of the cambiums at the top of the stock is most important, and further contacts below should be as continuous as possible. Tilting the cion outward is dangerous because the two cambiums may cross at a point where the cion bevel waves inward, preventing contact. The top of the cion bevels should be flush with the top of the stock. If the split in the stock is accidentally made deep and the cions are held loosely, tie a strip of waxed or paraffined cloth around the stock and leave it for about three months, after which it must be cut loose but not removed.

All cut surfaces should be carefully sealed with grafting wax. Check each graft before leaving to be sure there are no pinholes left unsealed. Holes in the wax permit moisture to escape, resulting in a drying of the tissues and a poor or no "take." Seal the split in the stock with wax, also.

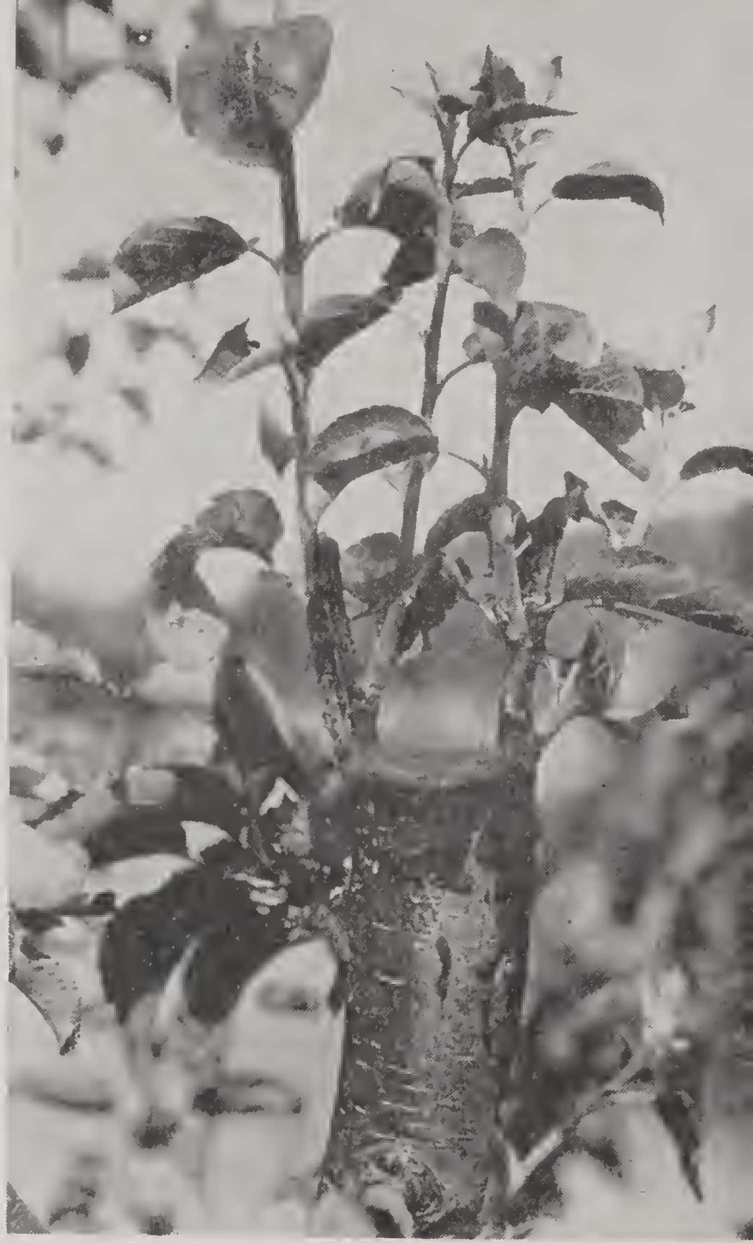
Over 90 per cent of the cions should take if the job has been done carefully. Common causes for failure in cleft-grafts are (1) failure to obtain proper cambial contact because of uneven bevel edges on the cion, (2) imperfect waxing, (3) lack of dormancy in the cion, (4) cion too thin and weak, and (5) fire blight bacteria which may infect the union.

The cleft-graft shown in Figure 94 shows an excellent "take" three months after grafting.

Bark-grafting. Bark-grafting can be readily understood by studying Figure 95. It is preferred by some operators to the cleft-graft because it is not necessary to split the stub and it can be used on stubs too large for cleft-grafting. However, it is questionable if a stub larger than two inches in diameter should be grafted, and it is certain that bark-grafts, especially on large stubs, are more easily blown out by wind than cleft-grafts.

The graft is made rather late in the spring when the bark slips readily. The cion is prepared with a one and one-half-inch bevel as indicated in the accompanying figure, laid against the bark, traced with the knife point, the bark on the stock removed, and the cion nailed in place with two three-fourths-inch brads with wide heads. This type of graft has been used somewhat more successfully with pears than with apples and cherries.

Recently, the Michigan Experiment Station has modified this procedure and sped up the operation. It works best with pears. Instead of a slot for the cion, a single longitudinal slit in the bark is made. The bark along the slit is raised by insertion of a smooth, thin, and narrow hickory wedge. The cion is trimmed with a rather long bevel on the inside and a thin bevel on the outside, slightly deeper than the cambium. The coin is inserted under the hickory wedge as the latter is withdrawn. Cions and bark are held in close contact by wrapping the stock with nurserymen's tape, then waxing exposed areas.



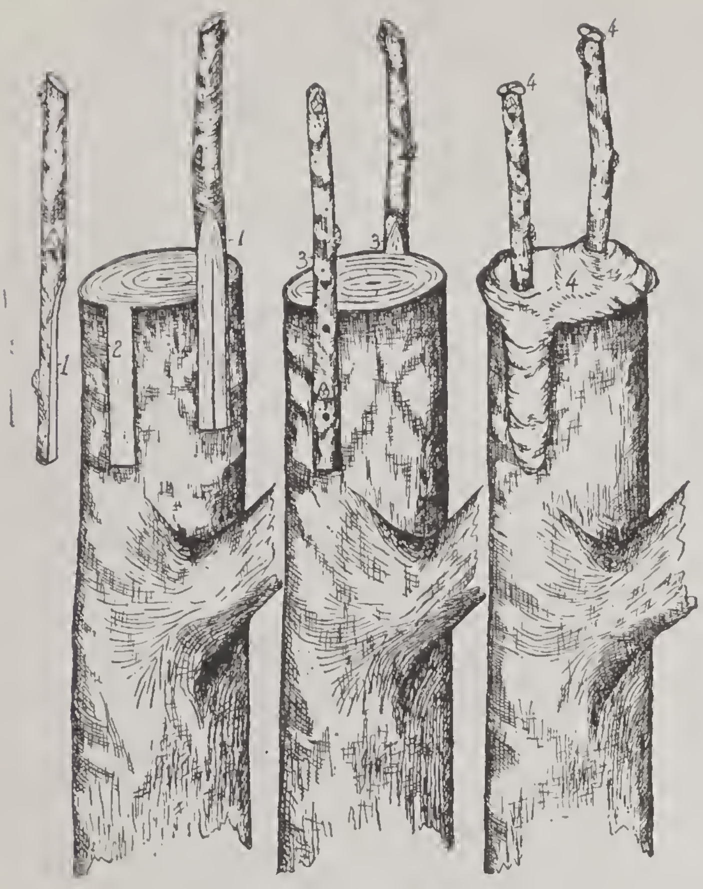
G. C. Pace, U.S.D.A.

Figure 94. A vigorous three-month's growth of cions in a cleft-groft. Note temporory retention of nurse shoots close to the cions, ond the excellent sealing of the union with wax.

SUBSEQUENT CARE OF GRAFTS

Careful attention to the grafts for a few years afterward is highly important for two reasons: (1) the prevention of invasion by wood-rotting fungi, and (2) to encourage correct framework development of the new top. Where two or more cions have been set in a cleft- or a bark-graft, the one making the best shoot growth should be encouraged and pruned as little as possible. The others should be nipped back over a two-year period, beginning the second year. When the stock wound has healed over, the subordinated cions are removed entirely. Presence of these subordinate cions is highly important in healing over the stump. If one cion should die, a near-by water sprout may be encouraged for awhile as the "subordinate" cion.

Grafts should be checked a short time after made and rewaxing done where necessary. Also, rewaxing should be done each fall and spring until the stub has healed over with callus formation. As the cion grows, it may loosen and chip the wax, in which case the wound should be cleaned and an entire new coating applied. This is not necessary with asphalt emulsion, however, which remains pliable.



Dept. of Pomology, Cornell University

Figure 95. Bark-grafting. (1) Cions are cut ready for nailing; (2) bark on the stock has been removed, exposing cambium cells, and is ready for close fit with the cion; (3) cions are nailed in place; and (4) cut surfaces are thoroughly waxed.

Both cions on a cleft- or bark-graft should be allowed to grow the first year. If the desired cion is growing very vigorously the second year, four to six inches of the tip should be removed about July 1 in order to induce branching if this is desirable in forming the framework of the tree. If there is likelihood of sunscald on the larger limbs, some water sprouts should be encouraged for temporary shade, then stunted and removed.

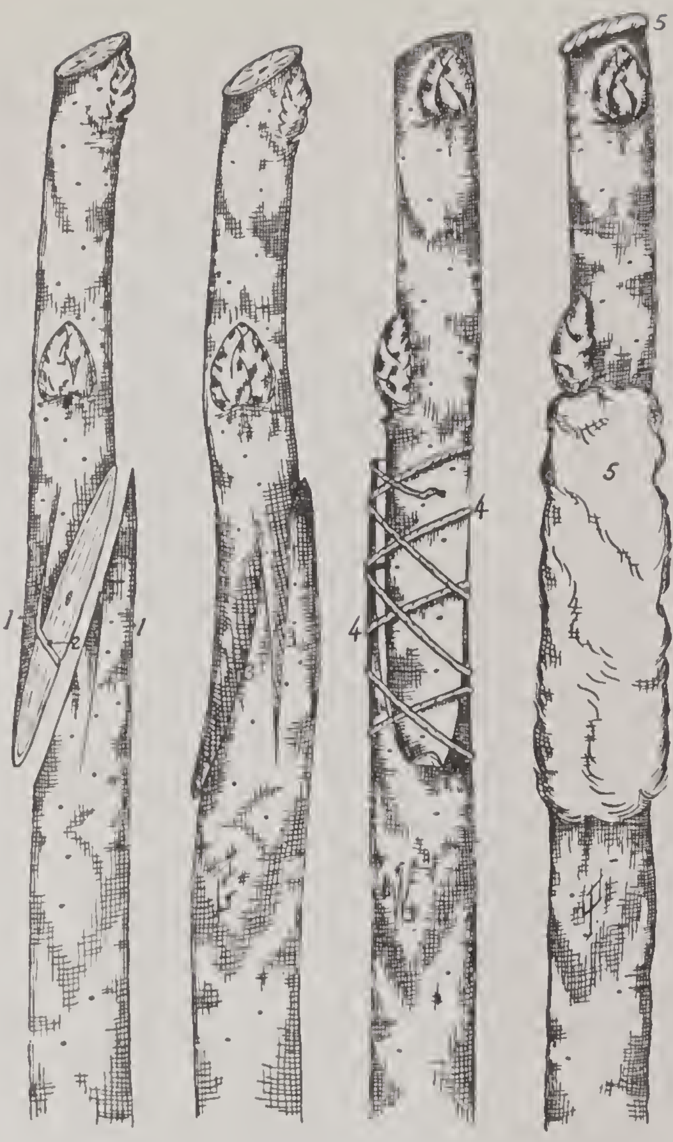
Inlay-grafting. Inlay-grafting is a promising method developed by the Michigan Experiment Station for top-working large trees where it is difficult or impractical to cleft-graft stubs larger than two inches in diameter. Grafting is done late in the spring when the bark slips readily. Cions somewhat thicker than a lead pencil are best. The cions may be two to six inches long, including one or more buds. A bevel to the pith is made the entire length of the cion which is then inserted in a prepared slot, nailed, and waxed. The cut in the stock is made by laying the prepared cion on the scraped stock and tracing around it with the point of a knife. All the bark must be removed to the sapwood in order that the two cambiums come in contact. After the graft is made, it is necessary to make two slits to the sapwood in the stock, one on either side parallel with the cion, and two inches from it. No wax is applied to these cuts. This prevents the growing bark from pulling away from the edges of the cion.

These cions should be placed within two or three feet of the main crotch and on scaffold limbs approaching a 45° angle; almost vertical limbs are unsatisfactory. The cions should be placed somewhat on the sides of the scaffold limbs, and not on top, for best results.

After shoots from these grafts have grown two or three years, the best can be selected for permanent scaffold limbs. The top of the tree over a period of from four to six years or more can be gradually opened to admit more light and room to these new limbs, while the old scaffold limbs are gradually pruned away and eventually removed.

This method of top-working an old tree has the advantage of not interrupting cropping so seriously as with other methods.

The tongue- or whip-graft. The tongue- or whip-graft is suited to top-working young trees in the orchard where the stock and cion are small and about the same size. It is also used for bench-grafting inside in winter where the cion and seedling roots are grafted together, wrapped with string, stored in moist peat moss, and set in the field for the purpose of developing nursery trees, as described in Chapter II. The method of matching the stock and cion (with two to four plump buds) is shown in Figure 96. The uniformly sloping bevels are from one to one and one-half inches long. On both stock and cion, a slit is made halfway between the pith and the end or toe of the cut. The two are then slipped together as indicated. If the cion is smaller than the stock, union of the cambium should be provided on only one side. If the ends, or toes, of the stock and cions should hang over, these must be trimmed flush. In the orchard, the graft is then wrapped with rubber bands, No. 18 waxed string, or nurserymen's tape. Exposed areas are thoroughly covered with grafting wax. A young apple tree top-worked in this manner is shown in Figure 97. Whip-grafting can be done from the time before the bark slips to after-bloom, provided the cion wood is dormant.

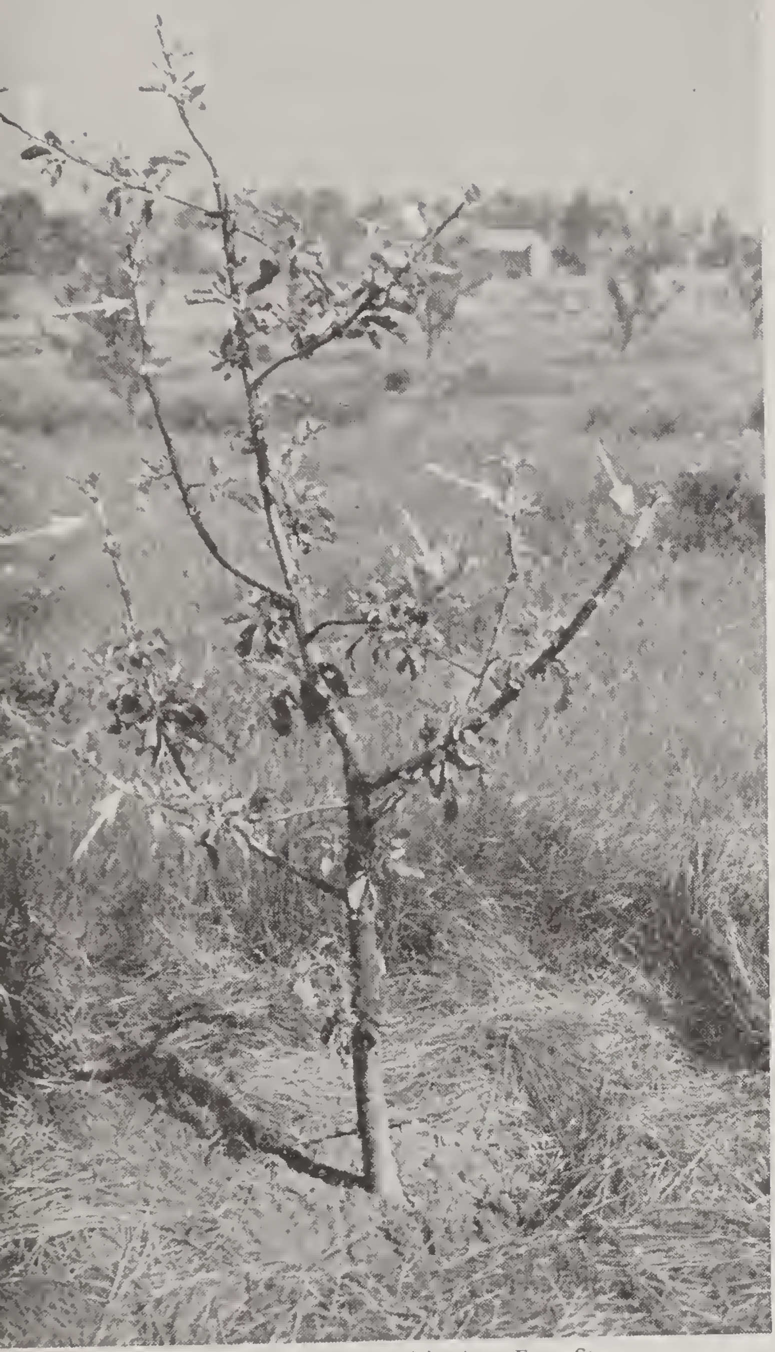


Dept. of Pomology, Cornell University

Figure 96. Steps in whip-grafting are shown above. (1) Cion (top) and stock (bottom) prepared by diagonal bevel cuts from one to two inches long. (2) From one-half to three-fourths-inch cuts are made with the grain, starting midway between pith and tip of bevel cuts. (3) Stock and cion united with cambium layers in contact on one side. (4) Waxed string or rubber strips aid in holding stock and cion firmly. (5) All cut surfaces thoroughly waxed.

Beginners may not be successful with this graft because of: (1) failure to make the sloping cut long enough, (2) uneven bevels arising from a dull knife or other causes, (3) improper placing of the slit, and (4) failure to press the tongues together deeply enough.

It requires about a month after growth starts for the union to take place,



C. W. Ellenwood, Ohio Agr. Exp. Sta.

Figure 97. Whip-grafting has been performed one week previously on nine (see arrows) desirably placed scaffold limbs and the leader limb of this Virginia Crab apple tree (on French Crab seedling roots). Spurs were left, but remaining branches removed. Note growth starting.

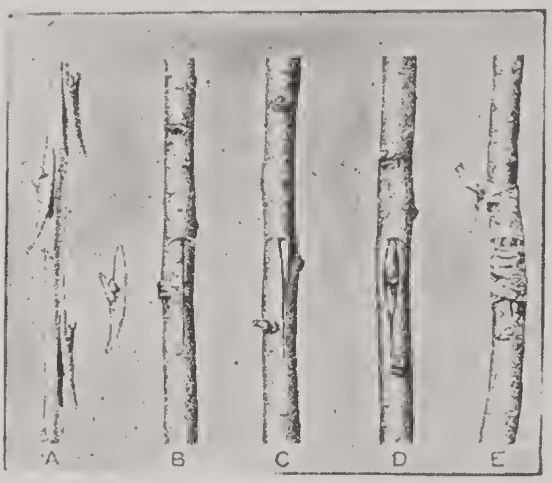
after which the rubber strips or string should be cut to prevent ringing. At this time select the best shoot from the cion, remove the others, and begin to properly train the tree as described in Chapter IV.

Budding. Budding is a form of grafting in which a bud is used as the cion rather than a section of the stem. Budding is used mostly on trees in the nursery. It also can be used in the orchard on young apple trees like the one shown in Figure 97, but whip-grafting is more common in this case. It is used for topworking peaches, plums, and cherries in the field because gumming is not excessive and splitting of the wood is not necessary.

Budding is done in late summer or early fall. Buds are selected from the middle portion of vigorous current-season growth. These growths are called "bud sticks." The leaves are trimmed off, leaving three-fourths inch of the petiole or stem attached for a handle in manipulating the bud later (Figure 98). The bud sticks are wrapped in moist burlap to prevent drying during the budding operation. Buds are more successful when inserted on the upper side and at the base of one-year wood where the bark is relatively thin. If the stock is one to three inches thick, as with peaches, a one-year side shoot is selected for budding, after which the stock is cut back the following spring just above the side shoot, and flush with it.

Using a special budding knife (Figure 90) a "T-cut" is made as described in Figure 98. The bud is removed from the bud stick by making a concave cut starting one inch below the bud. A transverse cut is made about one-fourth inch above the bud to remove it. After the bud has been inserted *upright* into the opened cut, it is snugly wrapped with raffia, electrician's tape, or a rubber band, taking care to leave the bud exposed. Ends of the raffia can be tied; ends of the rubber strips can be held in place by putting the free end back under the last turn. No wax is necessary.

If the graft is successful, the bud should grow to the stock within about two to three weeks, after which the rubber band, string, or tape must be cut to prevent ringing. The graft was successful if the bud is plump; if shriveled, it will be necessary to rebud. The next spring before growth starts, the stock should be removed about one-half inch above the bud in order to force the latter into growth. All shoots arising below the bud during the next season must be periodically removed.



G. E. Yerkes, U.S.D.A.

Figure 98. The *T* or shield bud. (A) Bud stick. (B) T-shaped cut through bark of stock. (C) Bark raised to admit the bud. (D) Bud in place. (E) Bud wrapped with raffia. Rubber strips or electrician's tape also can be used.

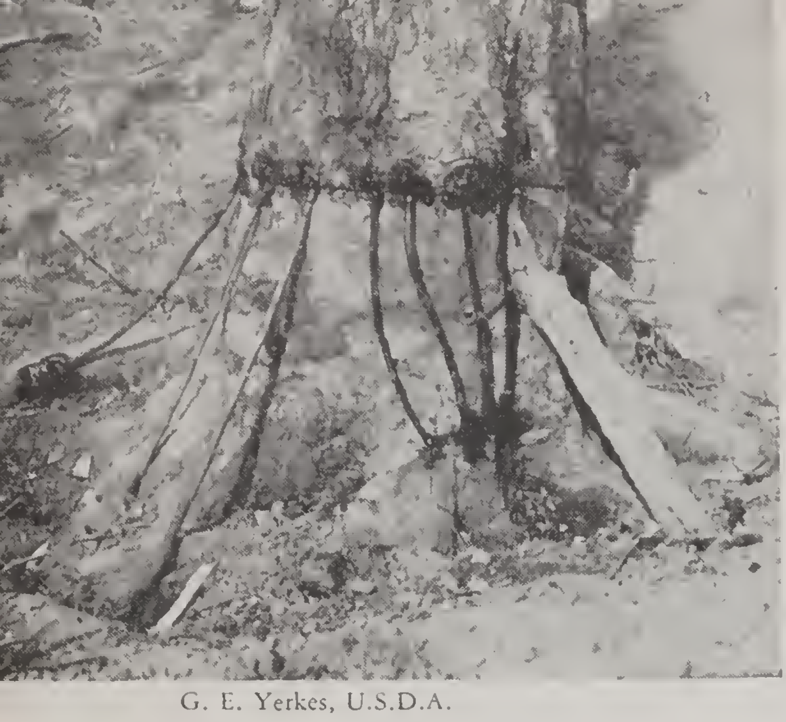
REPAIR-GRAFTING

Bark repair may be necessary on the trunk or base of the main limbs as a result of injury from mice, rabbits, winter freezing, cultivating tools, or disease cankers. Repairs must be done the spring after the injury occurred for best results. Large injuries which more than halfway girdle the tree and which have gone for more than one growing season may seriously weaken the tree and take it several years to recover, if such recovery is possible.

If bark has been removed by rodents during the winter, especially on very young trees, an application of asphalt emulsion or high-grade shellac should be made immediately to prevent excessive drying until a bridge-graft can be made. Grafting wax does not stick well to fresh wounds.

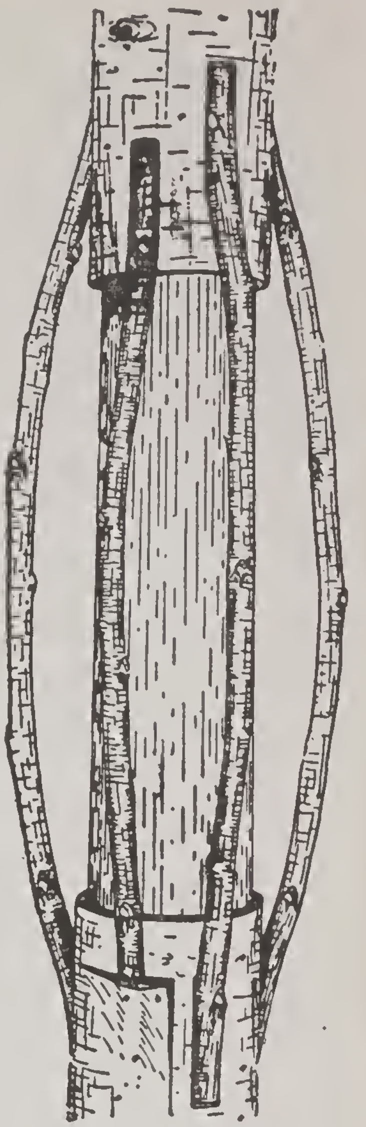
Cions for repair work should be selected from hardy disease-resistant varieties, such as Duchess, Fameuse, Northwestern Greening, Wolf River, McIntosh, Hibernal, and Virginia Crab. Undesirable varieties are Baldwin, Delicious, Golden Delicious, Gravenstein, Grimes Golden, Northern Spy, Rhode Island Greening, Rome Beauty, Stayman Winesap, Winesap, and York Imperial.

The bridge-graft. The bridge-graft is used to bridge over an area where the cambium is exposed or dead (Figure 99). On relatively young trees which have been completely girdled, the best procedure may be to cut them off at the girdle, causing shoots to appear, preferably above the nursery graft on the seedling root. If shoots arise from the seedling root, it will be necessary to whip-graft or bud them to the desired variety, or, the stump may be cleft-grafted provided it is strong enough to hold the cion. Cleft-grafting



G. E. Yerkes, U.S.D.A.

Figure 99. A bridge-graft over mouse injury which extends out on the roots. Asphalt emulsion is valuable for covering remaining exposed areas, after which dirt will be replaced.



H. A. Cardinell, Michigan Exp. Sta.

Figure 100. Bridge-graft showing three methods of setting cions. Cion set under flap at bottom is beveled on two sides. This method is timesaving on stocks with relatively thin bark. A bow in cions is important on young trees which sway with the wind. Cions are placed one to two inches apart around the trunk.

these small stumps may be preferable to bridge-grafting.

Bridge-grafting should be performed when the bark is slipping readily, which is about the first week in May in the northern states. Emergency bridge-grafting can be done in the summer, but careful selection of cion wood held over in storage is necessary.

The area to be bridged should be cleaned with a knife or a special bark scraper and painted with asphalt emulsion, preferably a day in advance of grafting to prevent the sapwood from drying and to facilitate the grafting job.

Cion wood for bridge-grafting can vary in size from that of a lead pencil to one-half inch in diameter, the large and longer cions being used on larger wounds. The cion should be cut at least four inches longer than the area to be bridged. Long cions are easier to manipulate than short cions. Therefore, if the area to be bridged is narrow, it may be better to inlay-graft the ends of the cion several inches above and below the injured area, using a long cion. The method of preparing the cions and nailing them in place is shown in Figure 100. The lower two- to three-inch bevel is prepared first, set in a close-fitting slot, and nailed. The upper bevel is then cut and placed against the stock and outlined with the knife, thence removing the bark slot. With young trees a small stick is placed between the center of the cion and the stock in order to give

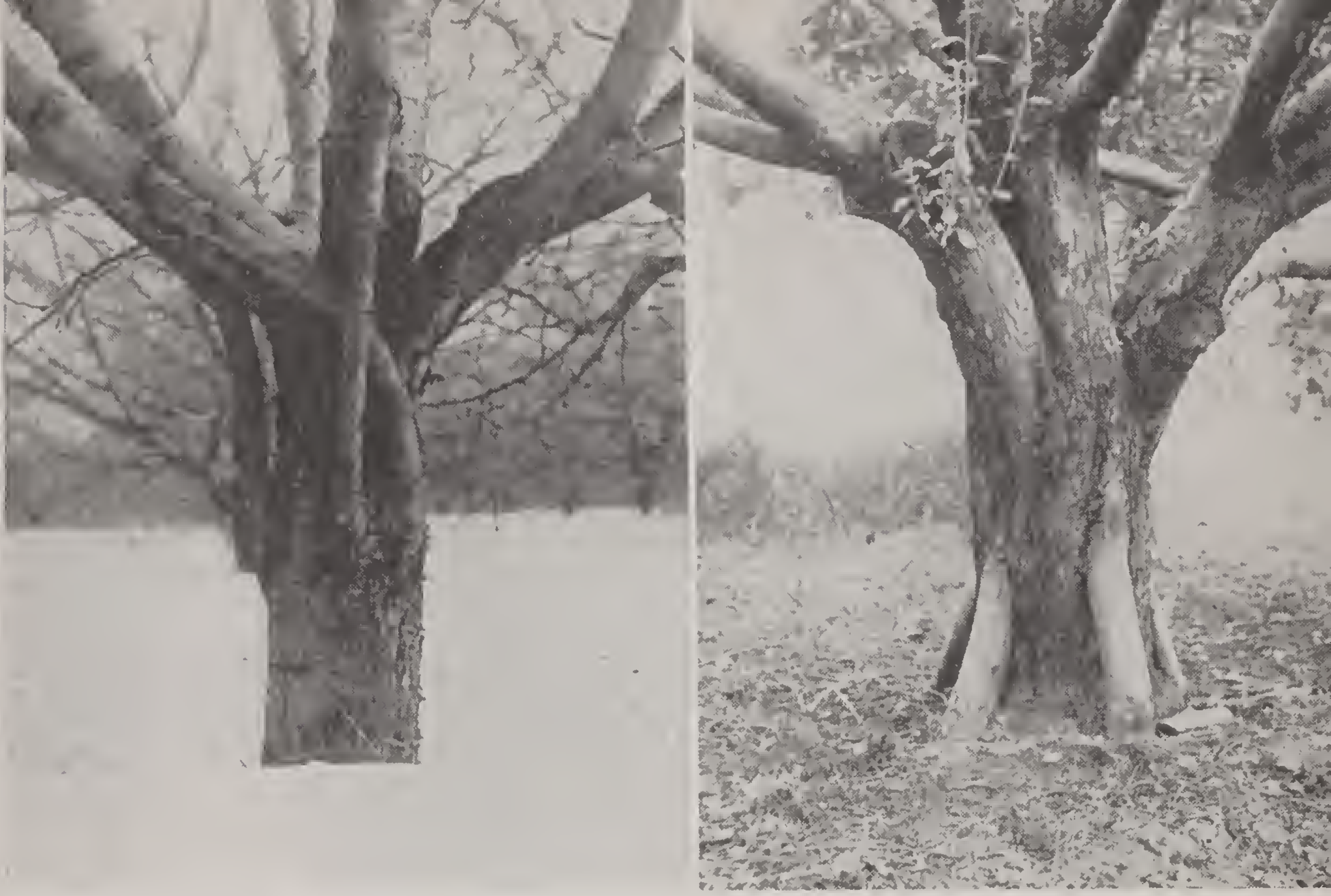


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Figure 101. (Left) A 6-year bridge-graft used for repairing fire blight damage on a mature apple tree. (Right) Inarching or approach-grafting may be used to repair pine-mouse injury to roots, or to increase the root system under shallow soil conditions, or for similar reasons. Four seedling apple trees have been planted at the base of the tree and inlay-grafted into the trunk. Grafts are 4 years old; cost was $1.50 per tree.

the cion a bow and prevent it from being pulled out as the tree sways with the wind. One must be careful to have all buds facing upward. Inverted cions have been noted growing in many cases, but the vigor and percentage "take" are lower. All exposed areas should be covered with grafting wax or the asphalt emulsion. After the bridge-graft has been made, it should be protected from future rodent injury by precautions outlined in Chapter IV under soil management. No protection is necessary if the bridged area is above the reach of mice and rabbits. Remove water sprouts arising on and near the cions at frequent intervals the following season.

The approach-graft. Approach-grafts are shown in Figure 101. One or more nursery trees, from one to two years old, are planted at the base of the tree. Tops of the trees are inlay-grafted into the trunk similar to the contact made in case of the upper end of the cion in bridge-grafting. This type of grafting is useful where the mature tree has received a bark or canker injury a few years previously, and grafting has been neglected. Many of the roots may have died and the limbs in line above the injury may have become weakened. Some growers have practiced approach-grafting on trees growing on shallow soil in order to increase the amount of root system, but experimental data to confirm this practice are lacking. It is important to remove all suckers and side branches appearing on the seedling trees or the trunk of the mature tree until the young trees are well established.

Review Questions

1. Give at least 5 reasons why a knowledge of grafting is essential in orcharding.
2. Give the qualifications of good cion wood.
3. When is cion wood selected and how should it be stored until used?
4. What is the cambium and where is it located?
5. List the essential equipment needed in a grafting outfit.
6. Draw a diagram to show proper insertion of a cion in cleft-grafting.
7. Why is the inserted bevel in the cleft-graft wider on one side than the other?
8. If the cion is smaller than the stock in whip-grafting, what procedure is generally followed?
9. In a 10-year apple tree, what limbs should be selected for cleft-grafting the first year, and which ones the second year?
10. What is a "bud stick"?
11. Why are grafts waxed?
12. What are the advantages of water asphalt emulsions over the standard brush wax?
13. For what age apple trees are the following methods of grafting best adapted?
    (1) cleft-graft
    (2) bark-graft
    (3) bridge-graft
    (4) whip-graft
    (5) budding
14. What periods of the year are best to perform grafting methods given in question 13?
15. Briefly discuss subsequent care of a (*a*) cleft-graft, and (*b*) bridge-graft.
16. Are roots ever bridge-grafted?

Suggested Collateral Readings

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CHAPTER IX

Freezing Injury to Apples

Probably the most important factor influencing the distribution of the fruit industry is minimum winter temperatures. They more or less mark the boundaries where certain fruits can be grown. In any fruit region, however, unusually low temperatures occur at times, causing widespread damage to fruit plants normally grown in that region. Also, some freezing injury occurs to nut and fruit trees in almost every region every winter. This is probably due to the fact that man tends to introduce economic fruits as widely as possible, often beyond the limits of their natural temperature tolerance.

At times, some people seem to think that the climate has changed and that more severe winters are being experienced. The available literature reveals that this is hardly true. Severe winters have been occurring periodically in the United States for at least the past 165 years at the ratio of about one severe winter in nine, but there appears to be no rhythm to their occurrence. Very cold winters may occur in succession for a few years followed by none for several years. Since 1900 "test winters" have been reported in 1903–04, 1906–07, 1911–12, 1917–18, 1933–34, and 1935–36.

Winter injury is not confined to the northern and central states alone. Greatest injury to deciduous fruits[1] in the South usually occurs when rather extended warm spells in the winter are followed by moderately cold periods.

How freezing kills. As yet, there appears to be no complete agreement among investigators as to how freezing kills. Different workers have presented different theories, each supported by rather extensive experiments and observations. In the light of recent research, W. H. Chandler con-

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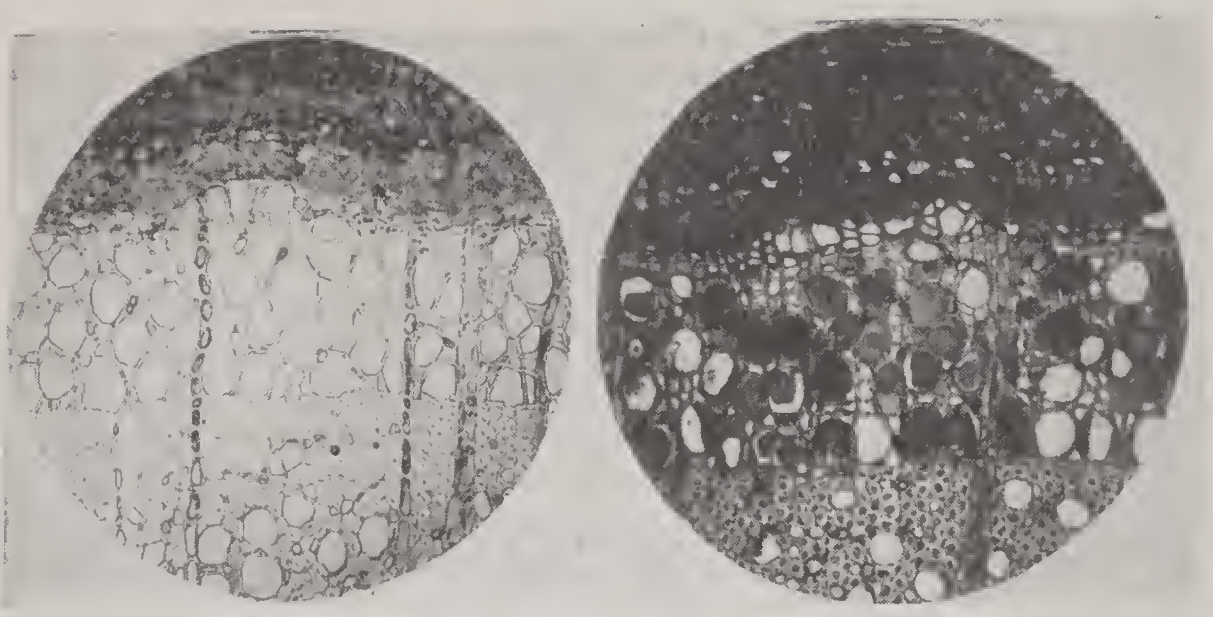
[1] Deciduous fruits lose their leaves during dormancy.



M. T. Hilborn, Maine Agr. Exp. Sta.

Figure 102. Sapwood from apple tree on the left is uninjured. That on the right was injured by the severe winter of 1933–34, and it shows characteristic clogging of the vessels with a black gum. This injury is often termed "blackheart."

cludes that death by freezing is dependent upon ice formation in the tissues. For it is known that, with no jarring, plant parts can be slowly cooled without ice formation to several degrees below their normal killing temperature; if plant tissues so-treated are then warmed to above freezing without ice formation, no injury occurs. Furthermore, it is known that pollen grains which contain relatively little or no water can be subjected to temperatures as low as —328°F. without injury to them. But if these cells are permitted to absorb a little water, ice forms and they are killed.

Chandler cites another probable explanation (Sach's) for killing of tissue by ice formation. When the ice masses in the protoplasm thaw, the protoplasm may become disorganized and killed by chemical substances forming as a part of an oxidizing system. It is true that ice masses have been observed both inside and outside the protoplasm while the tissue is frozen. Another possible explanation for cell death is an excessive strain upon the protoplasmic layer as a result of its rapid and perhaps uneven contraction when water moves out and freezes between the cell walls, or, between the walls of each cell and its protoplasm.

Wood which has been injured by freezing shows not only death of many of the cells in the sapwood, but also a clogging of some vessels with a black gum formation (Figure 102). After the severe freeze in 1933–34 in Maine, it was discovered that trees showing about a 50 per cent death or clogging of cells in the sapwood usually did not recover, whereas those showing only 20 per cent damage often recovered.

The amount of injury from freezing in dormant tissue is influenced by three factors: (1) the rate at which the temperature falls, (2) the duration of the low temperature, and (3) the rate of thawing. It appears rather certain that the more rapidly the temperature falls, the greater is the injury for the minimum temperature attained. Thus, injury under such conditions may be produced at a higher temperature than if the rate of fall had been gradual. Almost everyone can remember nights when the temperature dropped exceedingly fast to low levels. It is these nights which are likely to be the most damaging to plants, and which probably account for most of the severe injury to fruit trees. If rapid drops in temperature are accompanied by strong wind, the tissues are naturally cooled faster, and the damage is accentuated.

The longer the cold period, the more the freezing injury at a given temperature. According to G. F. Potter, the increased injury under these conditions may be due to death partly from desiccation as a result of cold drying winds; water movement in the tree is very slow at low temperatures.

Freezing injury is greater the faster the frozen tissue thaws. Often, but not always, after spring frosts when the leaves have been frozen, the shaded leaves and fruits are damaged less than those exposed to bright sunlight. In addition, apple fruits show less browning and breakdown if they thaw slowly at a temperature of about eight degrees above freezing than if thawed rapidly at a higher temperature.

Hardiness of tissues. The relative hardiness of tissues is different in winter and summer. When the tree is in active growing condition, the more active the cells, the more susceptible they are to cold temperatures, which means that the cambium layer and newly developed cells on either side are the first to be killed. This was clearly shown in an unusual cold wave occurring between November 11–15, 1940, in an area following roughly the Missouri River Basin, including Iowa, Missouri, Nebraska, and Kansas. The autumn had been unusually warm with sufficient moisture to keep the plants in active growing condition. The crop of fruit, in general, had been heavy and the trees were still in leaf when the storm struck. At Ames, Iowa on November 11, T. J. Maney reports the morning temperature was 51° F.; by noon, a 50-mile gale of wind developed, and by night, a temperature of 9° F. was recorded. Minimum temperatures on the four succeeding dates were 4°, —2°, 2°, and —2° F. Injury assumed all forms common to low-temperature midwinter damage, except root killing. Because of the active condition of the cambium in the tops at that date, many of the trees were killed outright. In some cases no sprouts appeared from the apparently uninjured roots, probably because little food had been stored in them by the time of the freeze and, also, as a result of the heavy fruit crop the tree had matured shortly before.

When the tissues have become well matured by the middle of winter, the cambium becomes the most resistant to freezing, followed in order by bark, sapwood, and pith. In fact, laboratory experiments have shown that well-matured cambium during the winter season cannot be frozen at temperatures considerably lower than those occurring in orchards. In the roots, the cambium seems to be the most susceptible to cold followed by the bark, with mature sapwood and pith the most resistant.

Apparently, an accumulation of carbohydrates in the tissues is a most important factor contributing to maturity and hardiness. Trees which have carried a plentiful supply of healthy foliage during the growing season and which did not grow late in the fall, are usually the most resistant during "test winters." This is probably because abundant carbohydrates have been stored in the wood and bark tissues. This is borne out by the fact that varieties of apples which mature their crops early, such as Wealthy, Duchess of Oldenburg, Hibernal, and Yellow Transparent, are generally more hardy than varieties which mature their crops late. The late fall and winter varieties have the extra burden of ripening their crops and also storing sufficient carbohydrates to properly harden their tissues for winter.

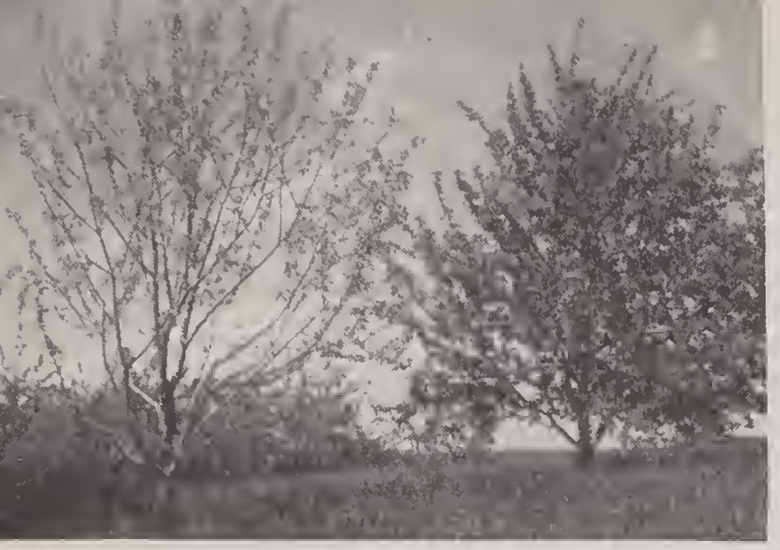
Trees with weak or limited foliage are among the first to be injured. Weak foliage may be due to poor soil drainage, nutrient deficiency, drought, or damage from caustic sprays, insects and diseases, or other causes. On the other hand, trees which have made excessive shoot growth and utilized most of their carbohydrates in growth tend to enter the winter poorly matured and are, therefore, readily susceptible to injury by cold temperatures. Thus, top-worked trees with many limbs recently removed may experience considerable injury during severe winters. Also, trees which have been cultivated late in the season, heavily pruned, and/or heavily fertilized are highly susceptible to cold.

All of these facts, as stated previously, indicate that conditions must be favorable for an accumulation of carbohydrates in the tissues in order that they be properly matured and hardened for winter. It is probably safe to say that a well-matured tree of a tender variety is more hardy than an immature tree of a hardy variety. This, if true, may account for many apparent inconsistencies in field observations of winter injury among varieties.

Any practice which tends to check the rate of tree growth in autumn, other than one which would cause premature loss of foliage, is likely to bring about better maturity and more hardiness. A vigorously growing cover crop planted in August or September is valuable from this standpoint by competing with the tree for moisture and nitrates. The various winter cover crops have been discussed in the chapter on "Soil Management for Apples."

Dormancy and rest period. The deciduous tree is said to be *dormant* when it is without leaves and there are no visible signs of growth activity. The *rest period* refers to that period during dormancy when the aboveground portions of the plant will not grow even though temperature, moisture, and other external factors are satisfactory for growth. The rest period is highly important to fruit plants because during this period they cannot be forced into growth by warm spells in the middle of winter, later to be killed during severely cold periods.

Fruit plants enter and come out of the rest period gradually. The earlier a plant enters the rest period in autumn, the sooner it emerges the next year; conversely, the later it enters, the later it emerges. Little difficulty is encoun-



M. T. Hilborn, Maine Agr. Exp. Sta.

Figure 103. An injured and an uninjured Gravenstein tree following winter of 1933–1934 in Maine. The cambium in the tree on the left remained alive, but the sapwood apparently was unable to supply sufficient water to the top due to death of many cells and clogging by the black wound gum. This photo was taken in September, 1934; the tree died the following year.

tered with the apple by warm spells which force the buds to open early, exposing them to killing temperatures. The apple emerges from the rest period slowly and is much less responsive than other tree fruits to early warm spells. The greatest difficulty with apples is from lack of maturity in early winter. With peaches, the rest period is often broken by January 1, and subsequent early warm periods may induce the buds to swell and open, only to be killed by freezes. With peaches in the southern region, a program of cultivation and fertilization with nitrogen, combined with relatively heavy pruning is followed in order to induce the trees to grow late in the fall and thus enter the rest period later. Under these conditions, they come out of the rest period later and are more likely to avoid late freezes. Such a practice in the northern states, however, would be disastrous, inasmuch as warm spells in the middle of winter are not a problem, but early winter low temperatures might be destructive to the immature wood.

The rest period of different plants can be broken prematurely by use of special chemical treatments, but with fruit trees it appears rather definite that subjection to low temperatures is the most important factor in breaking the rest. With many apple varieties, a certain amount of cold temperature around 0° F. is said to be required. If the trees do not receive the necessary amount of chilling for the particular fruit and species, they tend to come into leaf slowly and blossom irregularly.

Hardiness of varieties. After the severe winters of 1933–34 and 1935–36 in the northeastern states to Maine, it was definitely decided that the following varieties are tender to cold: Northern Spy, Stark, Baldwin, Gravenstein (Figure 103), Tolman Sweet, Ben Davis, Winter Banana, St. Lawrence, King David, Fall Pippin, Hubbardston, Fallawater, Roxbury Russet, Sutton Beauty, and Rhode Island Greening. Baldwin was among the most susceptible, accounting for considerable loss in acreage of apple trees in New England. Varieties considered hardy are: McIntosh, Fameuse, Cortland, Macoun, Hibernal, Virginia Crab, Charlamoff, Wealthy, Milton, Oldenburg, Melba, Lobo, Early McIntosh, Liveland Raspberry, and possibly Delicious. In Minnesota, the Harlson apple is well adapted because of its hardiness. Crab apples, in general, are hardier than the standard commercial apple varieties. Understocks which are commonly used today, including Hibernal and Virginia Crab, are known to be very hardy to winter cold.

Wood and bark injury aboveground. There are several types of wood and bark injury which may be classified as follows: (1) blackheart, (2) crotch injury, (3) crown and collar injury, (4) winter sunscald, (5) splitting of the trunk, and (6) the killing back of twigs and young branches.

Blackheart. This is one of the most common types of winter injury. The pith is usually killed and the heartwood is darkened (Figure 102) turning a shiny brown while the cambium and bark remain alive. Dark discoloration is attributed to the formation of a dark gum in the cells. With blackheart, the tree usually continues to grow and may form new sapwood and bark rather rapidly the following season, provided there is a sufficient amount of live sapwood, a good supply of stored food, and the early season weather is favorable to recovery. Blackheart is found in apples, peaches, plums, pears, and cherries alike following severe winters. It is often found in nursery trees, especially pears. It seems to be more weakening to young trees than to mature trees. It is highly recommended that nursery trees with blackheart be discarded.

If bearing trees affected with blackheart were in reasonably healthy condition before the injury, in most cases the live cambium will form a new layer of sapwood and bark rapidly, and the mature tree may recover and fruit satisfactorily for many subsequent years. The spring and early summer must be favorable to recovery and not excessively hot and dry. Limbs which are showing considerable blackheart tend to be brittle and may break with a moderate to moderately heavy crop. Wire bracing may be advisable on key limbs. Such wood is also quite susceptible to wood rotting fungi and areas exposed by pruning should be thoroughly covered with a good wound dressing, such as water asphalt emulsion.

Crotch injury. The bark, cambium, and sapwood in the crotches or forks may be killed when other portions of the tree are uninjured. This is said to be due largely to the fact that there is little foliage at the base of the scaffold limbs, especially on the inner and upper sides, and, as a result, these tissues mature last before going into the winter. The more upright the limb and the more narrow-angled the crotch, the greater the likelihood of injury in these areas. Injury may extend several feet up the limb from the crotch, particularly if a smaller limb has been removed during the summer in the region of the injury. If the injury is noticed shortly after it occurred, the bark can be tacked in place and covered thoroughly with water asphalt emulsion to prevent drying and to encourage healing. If the bark is rotting when first noted, the dead bark should be cut away, "pointing" the wound at the upper and lower ends, after which the exposed areas are painted with water asphalt emulsion. Crotches showing considerable injury become weak and should be braced with wire and screw eyes (Chapter IV). Among the varieties which tend to show more of this injury are Grimes Golden, Northern Spy, and Tompkins King.

Crown or collar injury. These terms refer to a winter killing of the bark at or near the ground surface. It seems to be common with Grimes Golden, Tompkins King, Gravenstein, Northern Spy, and Twenty Ounce. Grimes Golden often develops it shortly after coming into commercial production, and a large percentage of the trees may not live to be 20 years old before acquiring it. Portions of the bark may be killed on one side, or, the tree may be completely girdled.

In Indiana, collar rot of Grimes Golden is said to be caused by a *Phytophthora* species of fungus found on peony. In an epidemic in 1933, from 43 to 60 per cent of the Grimes Golden trees in Indiana were partially or completely girdled. The disease may attack the crotches as well as the trunks. A 16-16-100 bordeaux mixture spray is recommended for susceptible varieties (including Rome Beauty), applied when buds are swelling in spring at the delayed dormant stage. Cankers should be cut out and painted with bordeaux paint, then bridge-grafted or inarched with young trees planted by the trunk. Varieties susceptible to crown injury are now commonly double-worked. A resistant interstock variety is inserted between the seedling root and the fruiting top, and the top-working is done well above the crotches.

Winter sunscald. Sunscald on limbs may be caused in summer by excessive heat from direct sun rays. A similar injury may develop in winter on the southwest sides of tree trunks in the northern states and the northwest sides in the southern states. Winter sunscald, shown in Figure 104, appears to be due to a rapid drop in temperature on cold, sunny, still days in midwinter. The direct rays of the sun strike the exposed side of the trunk in late afternoon, raising the temperature considerably above that of the air. After sunset, there is a sudden drop in air temperature and a correspondingly greater drop in bark and wood temperature, resulting in this type of injury. Trees with low trunks where some shading from scaffold limbs occurs, are usually injured less than trees with high trunks. Some growers make a practice of white washing the southwest side of the trunks late in fall or shading the areas with boards or barrel staves.

Splitting of the trunk. Longitudinal splits in the trunk, often to the pith, may occur in extremely cold weather (Figure 104). If one happens to be in the orchard during such periods, an occasional trunk may be heard to "pop" as a result of these splits. They are thought to be due to a higher water content near the center of the trunk and preponderance of tangential strain in the woody tissues when under ice pressure. The cracks usually draw together when the temperature rises, and the bark subsequently calluses over. Cracks are quite common on sweet cherry. In some cases, the bark may peel back, leaving a rather wide wound. If the bark is immediately tacked down with wide-headed roofing tacks, and thoroughly covered with grafting wax, it may grow back, provided the cambium is alive and the tissues do not dry excessively. If healing does not take place, the dead bark should be removed and the open wound painted with water asphalt emulsion, then bridge grafted as soon as possible.

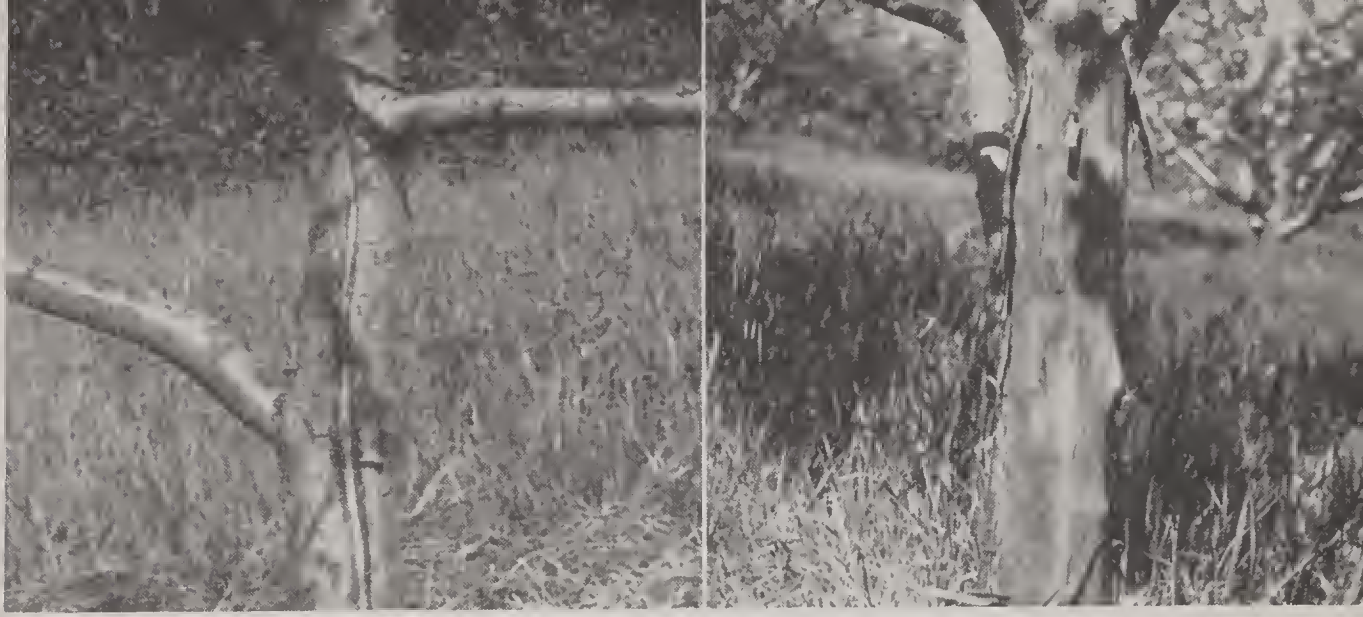


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Figure 104. (Left) Splitting of the trunk may be associated with rapid drop in temperature to low levels. The crack usually closes with rise in temperature; the bark calluses may heal rapidly the following season. (Right) Bark and wood injury, known as sun-scald, on the southwest side of a tree trunk is common in apple orchards. It is caused by rapid drop in temperature after sundown on very cold days.

Killing back of young branches and twigs. In a severe winter, this is common with many kinds of fruit trees, particularly if growth occurred late in the season and the twigs entered the winter poorly matured. The injury occurs frequently on young vigorous trees and seems to be an inherent characteristic with certain tender varieties. The effect of such injury is similar to pruning back the tips, inasmuch as the live buds nearest the injured area grow vigorously and the ends of the branches assume a bushy appearance.

Injury to leaf and flower buds. The leaf and flower buds of the apple are generally more resistant to freezing injury than those of most other fruits. The vegetative or leaf buds are about as resistant as the cambium in winter. There are a few cases where flower buds have been more resistant than leaf buds, but this is uncommon and occurs as a result of an early winter freeze. This is because flower buds harden sooner than vegetative buds. Later in the winter, however, the leaf buds develop more resistance to freezing than the flower buds. Flower buds of some varieties of apples will withstand —31° to —40° F. The buds tend to retain their resistance after the rest period is over, provided growth activity is not induced by extended early warm periods. In large commercial fruit producing areas, winter injury to fruit buds of apples is usually negligible.

Buds of the apple require a certain amount of winter chilling in order to open normally in spring. Apple trees grown nearer the Equator than latitude 33° to 34° may fail to open properly, or, if they do open, blossoming is uneven and the trees remain weak and produce small crops. In regions where cold weather begins about the first of November, the average temperature must be lower than 48° F. between the first of November and the first of February for proper opening of buds in the spring.

Killing of roots. Roots are not as hardy as parts of the tree aboveground. Roots of the apple may be killed at temperatures ranging from 5° to 19.4° F. Small roots are more susceptible to injury than large roots. Roots exposed aboveground during summer are usually more hardy than those which are covered with soil.

For several reasons, it is not necessary for the root to be as resistant to cold as the aboveground parts. The soil cools more slowly than the air and there is a certain amount of heat arising from the subsoil. For this reason, a very sudden drop in temperature after a warm winter day rarely kills roots. It is the long continued cold periods when the ground has adequate time to freeze that root injury is most prevalent. There may be some root killing every winter, and while this does not noticeably influence vegetative growth, it may have a definite effect on such a sensitive process as setting of fruit.

A heavy blanket of snow, a heavy mulch, or a good cover crop during the winter tends to protect the roots. Root injury is usually greater on gravelly or open soils than on a good loam. The worse injury, however, may appear on heavy, poorly aerated, or poorly drained soils, partly because the roots are nearer the surface and also because they are not properly hardened due to the somewhat weakened condition of the tree. More injury is likely to occur on hilly windswept locations where the snow may be blown away and the soil exposed to rapid cooling.

The commonly used French Crab and domestic seedling roots on apple trees are generally more sensitive to cold than roots arising from the cion varieties, or from the interstocks in case of Hibernal and similar hardy varieties. It is for this reason that whip-grafting of cion onto seedling root is preferred in areas where root injury is a critical factor. This is because the lower end of the whip-grafted cion can be covered with soil when planted, and roots often arise from it as well as from the seedling root. With the advent of the Harbin rootstock, however, W. H. Alderman at the Minnesota Agricultural Experiment Station indicates that budding is now satisfactory for propagating seedling trees.

If the roots of an apple tree have been largely winter killed, growth may start in spring, but the leaves and flowers soon show wilting. The tree may die shortly afterward, or, it may die slowly over a period of one to two years, depending upon the extent of the root injury. If one can be sure that the poor growth in spring is due to root killing (no evidence of bark injury aboveground), moderate to heavy pruning may assist the tree to recover. Pruning is definitely not recommended, however, for trees injured aboveground since the result has been repeatedly shown to be detrimental.

Treatment of winter injured trees. If there is little or no injury to the cambium and leaf buds, a tree may survive moderately heavy wood and bark injury. When the leaf buds open and growth starts, the cambium will develop both new sapwood and bark tissues and gradually replace the injured areas. It is important, however, that the cambium cells be kept moist; otherwise, they may die. As pointed out earlier, the loose bark should be nailed in place as soon as noticed, with wide-headed roofing nails and sealed with grafting wax. Strips of the bark, or the entire bark, may heal soon and help speed the recovery of the tree. The following late winter, obviously dead areas of bark can be removed (Figure 105) and bridge-grafted, or if the damage is near the ground surface or under the ground, young trees can be planted near the trunk and inarched into it. However, if at the outset it is clear that the injury almost or completely girdles the tree, and the cambium has dried, it is wise to bridge-graft as soon as possible.

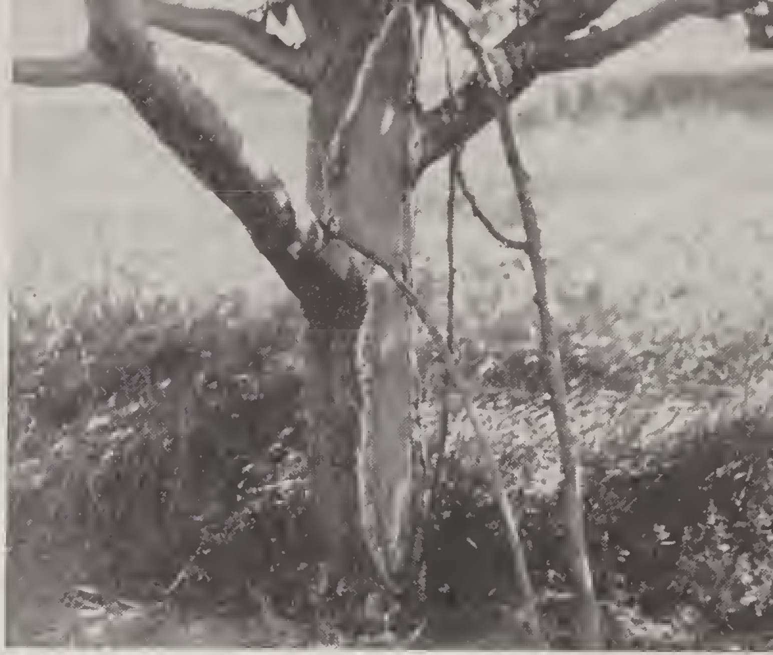

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Figure 105. McIntash trunk injured by 1933–34 winter in Maine. The bark and cambium in this area died. Treatment consisted af remaving the bark, "pointing" the waund, painting with water asphalt emulsion, bridge-grafting, and inarching young trees into trunk and scaffald limbs.

With trees which have received considerable sapwood injury after a severe winter, as evidenced by relatively weak growth in the spring, it is well to give them a moderately heavy application of nitrogen fertilizer in order to induce as much vegetative growth as possible and the formation of new layers of wood and bark by the cambium. Cultivation might well begin early in the spring to help stimulate vegetative growth in those orchards not being maintained in permanent sod-mulch culture. Pruning during the spring season immediately following winter injury is not recommended. Although pruning may seem to be a wise practice under such conditions, it has been pointed out previously that it has usually resulted in poor recovery or death.

If an apple tree sets a heavy crop of fruit following winter injury, the drain on the tree of such a crop may inhibit or prevent recovery. Fruit setting can be prevented by timing a blossom-thinning spray so that all blossoms are removed. (See Chapter VII.) Hand removal of all fruits shortly after setting is also effective, but more expensive. The use of caustic spray materials should be avoided on the foliage of winter injured trees. For example, mild sulfurs are safer than liquid-lime sulfur on apple foliage.

Review Questions

1. Distinguish between dormancy and rest period.
2. Give two probable causes for death of plant tissue by freezing.
3. Discuss briefly the susceptibility of the cambium to freezing injury during the growing season and the winter period.

4. List 5 cultural practices which influence maturity of wood and explain briefly how each affects maturity.
5. Give 5 types of wood and bark injury found in the orchard.
6. Explain why it is not necessary for roots to be as resistant to cold as the top portions of the tree.
7. What cultural practices reduce freezing injury to roots?
8. List 4 hardy varieties of apples and 4 tender varieties.
9. What treatment is recommended for winter sunscald on the trunk?
10. What cultural treatment is recommended for fruit trees which show moderately heavy winter injury as evidenced by slow and small leaf development in spring?

Suggested Collateral Readings

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CHAPTER X

Harvesting and Packing Apples

One of the most important periods in the life of a fruit is from the time it is picked until sold to the ultimate consumer. The grower cannot afford to become careless during this period in any one of the fruit handling operations. Actually, it costs no more to handle fruit carefully than to permit an accumulation of bruises, stem punctures, and press marks. It is not an overstatement to say that, "Fruit must be handled like eggs," for almost every bump will be readily apparent sooner or later, certainly by the time the fruit reaches the display counter. The trade quickly recognizes quality unblemished fruit and will pay a high premium for it.

PREPARING FOR HARVEST

Estimating yields. It is important that the grower develop an art in estimating crop yields several weeks before picking starts. This gives plenty of time to accurately determine the amount of labor needed, picking equipment to provide, the amount and type of packages to purchase, grading and sizing equipment needed, and the amount of storage space to provide or engage from commercial storage houses.

The ability to closely estimate the yield of fruit before it is mature comes only with experience in carefully studying the bearing habits of different varieties. Some varieties, such as Delicious (except in Northwest), have a tendency to fool the estimator, and fall short of expectations. McIntosh, on the other hand, is a good example of a variety which habitually does better than expected, because it bears heavily throughout the top of the tree.

The yields that one might expect from an acre of mature trees varies with the age, variety, number of trees per acre, methods of management, and the region itself. As pointed out in Chapter III, the average yield over a

Figure 106. Each picker is assigned a numbered picking container for which he is held responsible.

period of years in Eastern orchards has been about 1.7 bushels per tree, in Midwestern orchards—1.2 bushels per tree, and in Western orchards—four bushels per tree. In Washington State, orchards in the Yakima Valley average as high as six and seven bushels per tree. The above figures are based on the average production for all commercial orchards in the respective regions and, therefore, are in no way representative of the productive capacity of the better orchards. Well-managed orchards in the East may average over ten bushels per tree per year or from 300 to as much as 400 or more bushels per acre of packed fruit. In Washington State, it is not uncommon for some orchards to produce between 400 and 600 or possibly 1,000 boxes (45 lbs. per box) per acre of packed fruit under intensive cultivation conditions. To these figures must be added the cull fruit which goes into by-products, and does not justify packing costs. However, the alert grower constantly seeks to reduce this portion of low-grade fruit and to increase the quantity of quality stock. One of the better growers in Ohio reports less than 5 per cent culls with McIntosh almost every year; on the other hand, some growers report 25 per cent or more culls.

A crop estimator who is new at the game must be careful to base his estimate on average yields for many years, rather than on occasional bumper crop years. It is well for the grower to determine what the average yield is for his region and then through practices better than the average try to exceed this figure as much as possible.

An estimate of the yield should be made at three periods during the year: (1) after the crop has set, (2) after the "June drop," and (3) about one month before harvest. Five random trees per acre should be carefully inspected, being aware of the fact that heavier crops are likely to occur on outside rows, that a few trees may be carrying abnormally heavy loads, and that varieties with a limited number of trees should not be given too much weight. These estimates should be recorded in a notebook so that the grower can later compare them with the actual yield. If this is done year after year, he can eventually make estimates which will be of considerable value to him.

Providing needed equipment. On a lax or rainy day in midsummer, the grower should inventory all harvesting equipment on hand which is in usable condition. Each picker should have an assigned picking receptacle (Figure 106) which is designed to handle the fruit with as little bruising as possible. It should be light in weight, easily manipulated while the picker is standing on the ladder, and provide the picker with free operation of both hands. It is generally agreed that the half-bushel metal- or canvas-sided picking bucket with canvas drop bottom causes about the least injury to fruit under most conditions. It is suspended from the shoulder, hanging in front or slightly to the side of the picker, as shown in Figure 107. The bucket is padded on the inside and around the top with felt; the rigid sides also protect the fruit. It is easily carried and emptied.

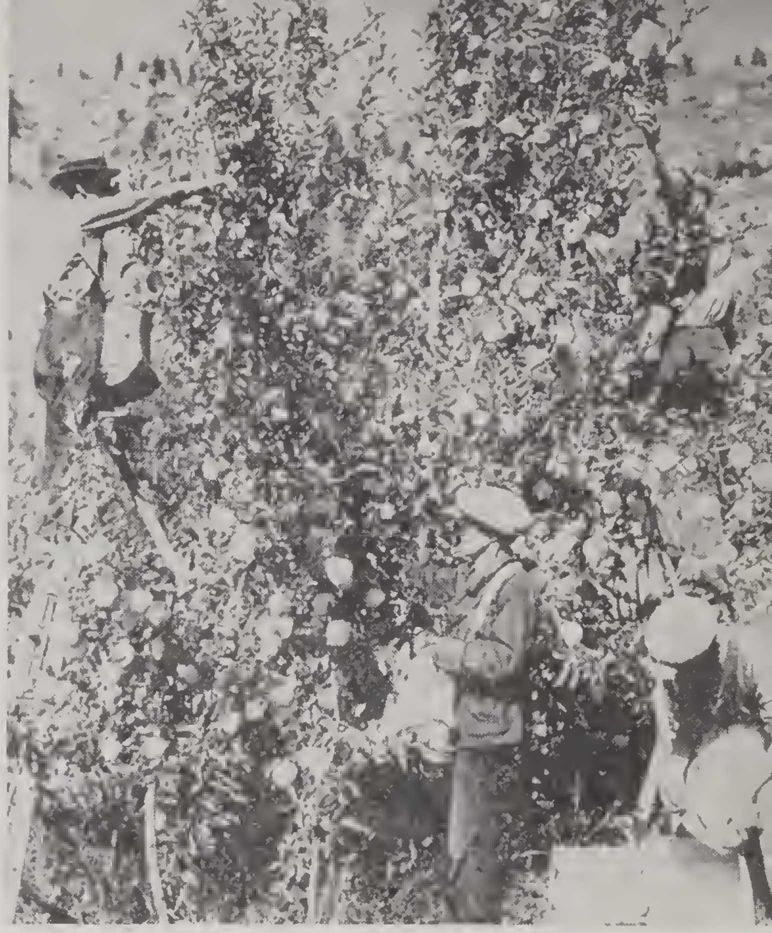

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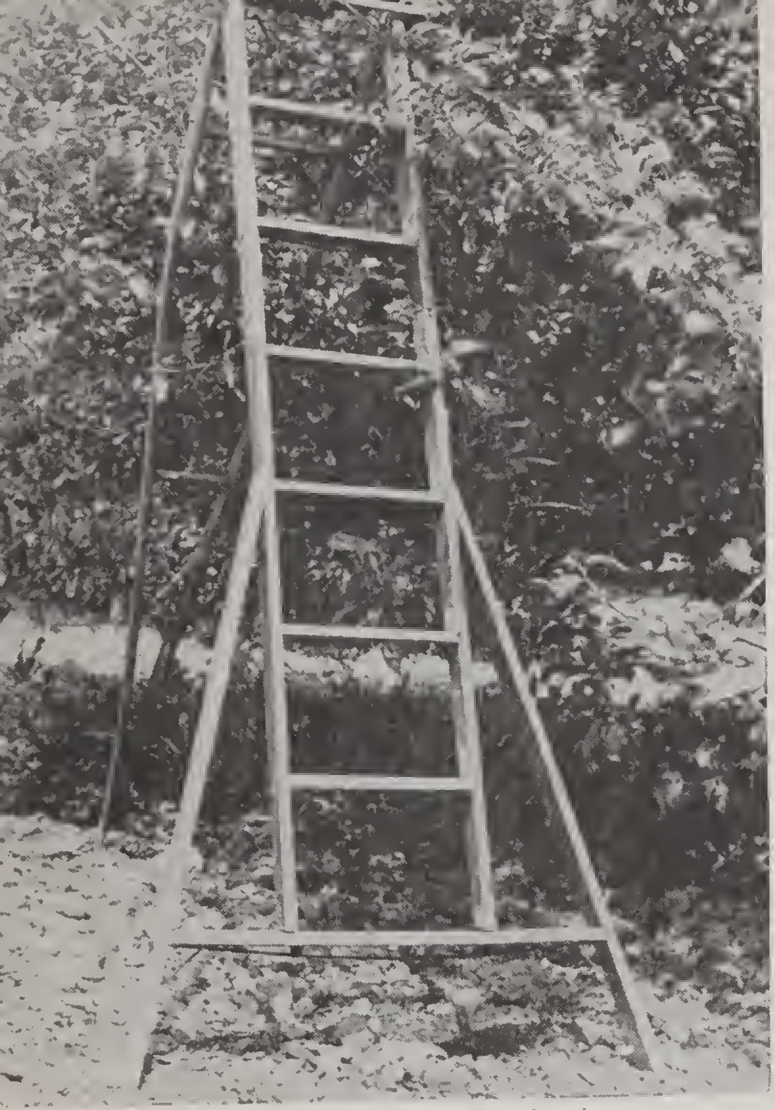
Figure 107. Picking buckets of the Wells and Wade type are preferable to picking bags because they afford more protection against bruising and stem punctures. In emptying the picking bucket into the field boxes, the canvas flap should be lowered to the bottom of the box so that the apples will slip out gently. Boxes should be filled to slightly below the top so they can be stacked without bruising apples.

Oak-stave baskets of one-half bushel or three-quarter bushel size are used in some orchards, but the picker spends too much time moving them about even though the handles are equipped with hooks. Also, it is not uncommon for a basket to be tipped or caught on a limb and partially or entirely dumped on the ground. Metal three-gallon pails are still employed by some growers because the foreman can hear and locate those pickers who are carelessly dropping fruit into the bucket. However, these pails have the same disadvantages as the oak-stave basket. Containers should be avoided which have sharp edges that may bruise or cut the fruit. Canvas picking bags which empty through the bottom are not first-class picking containers, because it is difficult for the picker to avoid bumping the fruit on the ladder rungs as he climbs down. True, any of the above containers may be satisfactory in the hands of a careful workman; any receptacle may be objectionable if carelessly used.

A ladder which is light, strong, and well balanced should be assigned to each picker who is held responsible for its care during the picking season. Choice of an easily handled and sturdy ladder is highly important because the picker spends considerable time climbing up and down the ladder and moving it from place to place. The picker should have confidence in its strength so that it will not detract from his working rapidly and efficiently. It pays to buy good ladders. Poor ladders are far more expensive in the long run from the standpoint of lost labor.

The ladder shown in Figure 108 can be placed well into the tree and set solidly on the ground. Taller or shorter ladders of the same style are on the market. For tall trees, however, rung ladders are best. The better rung ladders are flared at the bottom and tapered to a point at the top. Pointed ladders can be easily shoved between the branches and into small openings without disturbing the fruit.



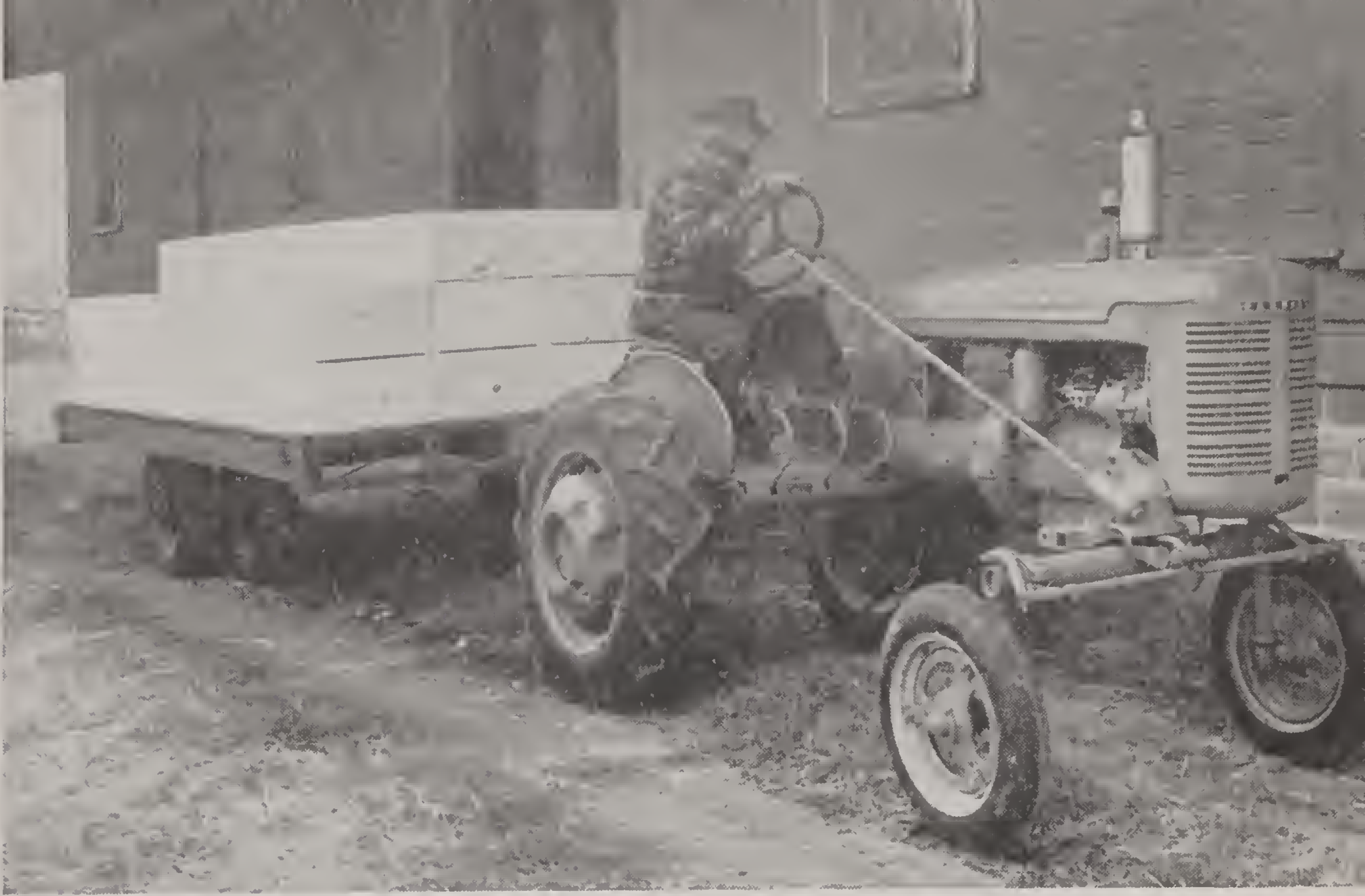
Dept. of Pomology, Cornell University

Figure 108. For the younger and lower trees, an eight-foot stepladder, aluminum or wood, with one support and a wide base is secure and can be placed well into the tree.

Twenty-eight to 30-foot ladders are available but these are difficult to handle for one man; a 22-foot ladder is more commonly used. Also, there is a definite tendency for growers to keep their trees around 20 feet or lower for economical management. It is surprising that the cost of harvesting tall trees is almost double the cost of harvesting low trees. Too much time and energy are spent climbing up and down a tall ladder during picking.

Fruit receptacles in the orchard. An orchard box, as shown in Figure 109, preferably with finger holes in the ends for lifting is a desirable container for field use at harvest time. These boxes are far superior to slatted crates because the walls are smooth with no sharp corners that bruise the fruit. Extra wood strips can be nailed either on the tops or bottoms of the ends so that the boxes can be stacked with less likelihood of mashing the fruit in the box below. Some growers use the final packing container as the field crate, in which case the new boxes are distributed through the orchard and the fruits drawn to the packing shed in them.

The trailer shown in Figure 109 is of desirable construction. The platform is wide, long, and capable of carrying a sizable load; it is about waist high and can be easily loaded. The trailer can turn sharp corners and is readily maneuverable among trees. The springs and rubber-tired tandem arrangement of the wheels reduce jarring of the fruit to a minimum. Jarring can



International Harvester Co., Chicago

Figure 109. A desirable type trailer truck for carrying apple boxes from the orchard. Tandem wheels reduce bumps to minimum; platform is low, wide, long, and accessible. The trailer and tractor can make sharp turns.

be further reduced by smoothing out ruts and rough places in the orchard roadways before picking starts.

In advance of the harvest season, an inventory should be taken on fruit packing containers. Types of containers to be used will be discussed later. However, it is essential that the grower order his supply as early as possible in order that he will receive high quality stock and have it on hand without delay.

Securing adequate labor. It is well to have a nucleus of capable and efficient workers, some of whom are hired throughout the year, to more or less take the lead in harvesting the crop. In established orchard sections, practically all workers have had a certain amount of experience in harvesting. In addition, there is usually a regular influx of "floating" labor which comes from many miles to work throughout the harvest season. The picking gang can often be completed with this transit labor.

In judging the amount of labor needed for harvesting a crop, the grower must consider the height of his trees, whether the ground is steep or level, and the amount of time available for picking each variety before shifting to the next. The following figures might be helpful. If the workers are paid by the bushel or box, it is not uncommon for them to harvest between 100 and 150 bushels a day, provided the trees are carrying a good crop and are relatively low with a broad bearing surface in proportion to height. On the other hand, if conditions are the same except the trees are tall and large, the amount of fruit an individual worker can harvest in a day is about half as much, or, between 60 and 75 bushels. Workers paid by the bushel or box usually pick more fruit in a day but, in general, they tend to handle the fruit roughly and include leaves and fruit spurs, which is bad practice. This varies with the crew and the foreman, however; under some conditions it may work quite satisfactorily.

Workmen hired by the day tend to work somewhat slower and cause less injury to the trees and the fruit. It can be roughly estimated that workmen paid by the day will harvest from one-third to one-fourth less fruit as compared with those paid by the box or bushel. When the quantity of crop to be removed is not great, day labor well supervised is probably best.

In case of a large crop, some growers may contract their entire crop to a buyer who takes responsibility for the harvesting, packing, storage, and marketing operations. This is a common practice with citrus.

Proper time for picking. In present day orcharding, a large percentage of the crop is stored in common or refrigerated storages before marketing. Apples may be kept in storage for a few weeks to several months. In order that they maintain dessert quality, storage capacity, and commercial value, it is highly important that they be picked at the *proper stage of maturity.* If picked prematurely, apples are likely to be small, poorly colored, sour, tough, off-flavor, and subject to functional diseases such as bitter pit and scald. On the other hand, overripe apples may develop water core while still on the tree, or, after picking, they are likely to suffer from soft scald and internal breakdown (Figure 110). With overripe red varieties, in some cases the color may become dark and dull and the skin become greasy or oily. Overripe apples, especially with some varieties, tend to be mealy and flat in flavor. In general, there is a period of about 5 to 20 days, depending upon the variety and climatic and cultural conditions, during which the fruit can be picked with reasonable assurance that it will be free from storage disorders and develop good dessert quality. It is important to note that the fruit continues to increase in size as long as it remains upon the tree. From this standpoint, it is desirable to leave the fruit on the tree as long as dropping does not equal or exceed the total volume increase. It cannot be predicted, however, when excessive dropping is likely to occur and, therefore, picking must start while the fruit is still adhering well.

The following methods are given for determining the proper time to pick. It should be borne in mind, however, that none of these is entirely dependable under all conditions.

Time elapsed from full bloom to picking maturity. It has been found by an extensive survey among the leading commercial apple states that the number of days from full bloom to picking maturity is rather constant over a wide range of climatic and cultural conditions. According to Haller and Magness, this seems to constitute one of the most reliable indexes of the earliest maturity date of many apple varieties. According to this survey, for example, the Delicious variety requires from 145 to 150 days from full

D. F. Fisher, U.S.D.A.

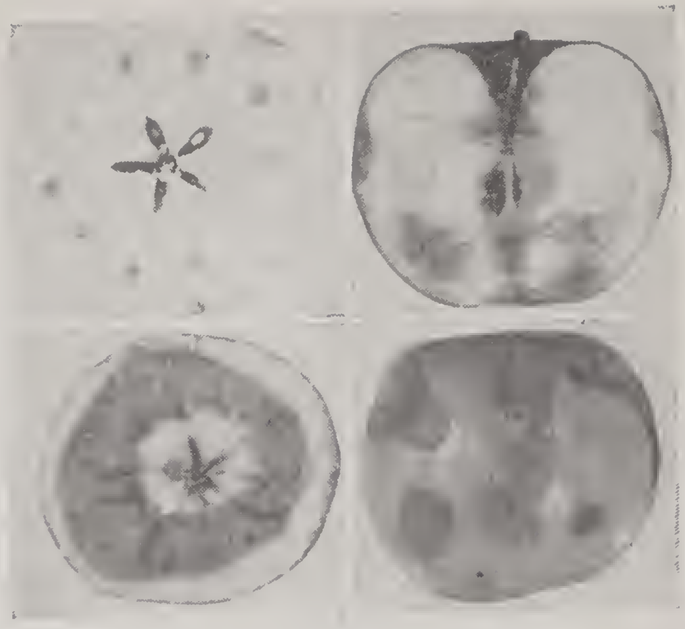


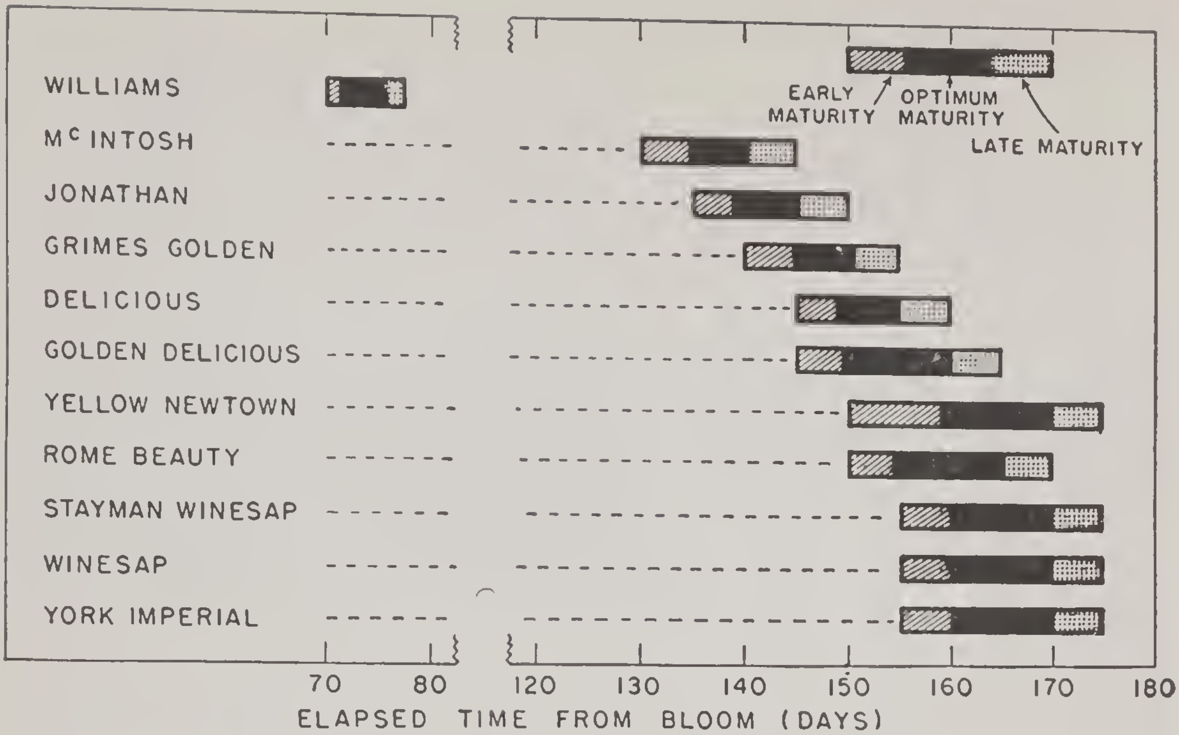
Figure 110. Common physiological diseases of apples apparently associated with overmaturity at picking time. (Top left) Water core, characterized by glassy or water-soaked appearance of flesh around the core or main vascular bundles. Such apples may eventually show internal breakdown. (Top right) Internal breakdown has general mealiness and brownish discoloration of the flesh. (Bottom left) Soggy breakdown. (Bottom right) Softscald makes the apples look as if they were rolled on a hot stove.

bloom to reach picking maturity. Mean temperature seems to have relatively little effect on this time interval with apple varieties. However, relatively high temperatures just preceding harvest tend to result in more rapid abscission. Heavy nitrogen fertilization may delay fruit color development and result in scald unless picking is postponed. On the other hand, dropping may be more pronounced from heavily fertilized trees than from those receiving medium or light fertilization. A light crop of fruit tends to mature somewhat earlier than a heavy crop. The extent to which these and other factors may retard or advance maturity has not been entirely established.

Full bloom is defined as that period when the first petals begin to fall. This period is readily established if the weather is warm during bloom. However, if the weather should turn cool after the king or center blossoms open, the period may be prolonged for a week or more and confuse the specific time of full bloom.

The days from full bloom to picking maturity for several popular commercial varieties on which considerable information is available are shown in Figure 111. The apples may ripen during the early-maturity period (diagonal hatch) under conditions that would tend to hasten maturity, such as a light crop. Apples ripening during the late-maturity period (cross hatch), due perhaps to too much nitrogen, may become overmature and excessive dropping is a definite possibility. The period of optimum maturity, shown by the black area, is the number of days during which the apples can be picked for best handling and storage quality. The approximate time elapsed from full bloom to maturity of varieties other than those given in Figure 111 has been given in Table 6 in Chapter III.

The results of R. M. Smock at Cornell University might be cited as an example of the fact that this method of determining fruit maturity apparently does not always hold. For over ten years previous to 1945 at Ithaca, New York, a range of at least ten days was found from year to year for the period



M. H. Haller and J. R. Magness, U.S.D.A.

Figure 111. Days elapsing from bloom to maturity of fruit for 11 varieties of apples. The period of early maturity, as shown above, is when barely satisfactory maturity of the fruit normally occurs, but optimum maturity may advance to this period under conditions that would tend to hasten maturity. Similarly, the period of late maturity is when overmaturity or dropping may become imminent, but optimum maturity may extend into this period under conditions that retard maturity.

in which McIntosh should be picked. During the 1945 season, bloom occurred one month early and yet apples were picked within a few days of their usual picking date. In this case the number of days from full bloom to harvest was 154, whereas the average for McIntosh at Ithaca, New York is 127–130 days.

Ease of separation of fruit from the spur. When an apple is ready to pick, it can be separated from the spur without breaking the stem by lifting it with or without a slight rotating movement. There are popular varieties, however, such as McIntosh and Delicious, which may loosen and drop before maturity as a result of early frosts or other factors. On the other hand, there are certain varieties, as Jonathan and Stayman Winesap, which may retain their fruit until it is overmature. Thus, ease of separation of fruit from the spur is not necessarily an indication of proper maturity, but it may indicate when picking is necessary in order to save the crop. If no sound fruit is dropping and the fruit can be picked only with considerable effort, it is considered that the apples are still firmly attached to the tree. However, if a few sound apples are dropping and similar fruits can be separated rather easily from the tree, it is definitely time to pick the crop. One should not be misled by the dropping of wormy or otherwise injured fruits.

In recent years harvest sprays, as described later, have been used by some growers to make the apples "stick" to the tree longer. Naturally, with the use of these sprays, this index is of little value and, in fact, the fruit may tend to hang too long and become overmature.

Change in ground color. The ground or undercolor of an apple is a more reliable index of maturity than the red or overcolor. When most varieties of apples become mature, the ground color changes from a leaf green to a lighter shade and eventually to a yellowish color. With most varieties, the time to pick is when the first signs of yellowing begin to appear. However, with McIntosh, Jonathan, and Cortland, the fruit sometimes drops excessively before the color change takes place. This criterion of maturity cannot be used on red bud sports which become red all over before they are mature, leaving no uncovered ground color for observation. The usual result is that these red sports are picked before mature, resulting in the usual storage and flavor difficulties associated with immaturity. It has been found, however, that the red bud sports do not differ greatly in picking maturity from the parent varieties. Therefore, one could use the ground color of the parent variety as an indication if such parent varieties are in the orchard. A color comparison chart has been devised by the U. S. Department of Agriculture for use in determining picking maturity by change in ground color from green to yellow. These are available through the U. S. Plant Industry Station at Beltsville, Maryland.

Firmness of flesh. As fruits mature and ripen, there is a decrease in firmness of flesh. Firmness of the flesh can be determined by removing a thin slice of the skin and flesh with a knife and using a special hand-operated pressure tester which records the pounds pressure necessary for the plunger to penetrate the flesh. In conjunction with other criteria mentioned previously, this method of determining maturity is an additional useful index. Used independently of other criteria, it is of value chiefly in determining when apples are too soft and ripe for storage, rather than when picking should begin. However, one must take into consideration that factors such as temperature of the fruit, degree of skin redness where sample is taken, thinning, soil moisture, and rootstocks may also influence the readings and mask the relation of pressure test to maturity and ripeness.

Pressure-test records have been transposed into ordinarily accepted commercial designations of "hard," "firm," "firm ripe," and "ripe." Publications listed at the end of this chapter should be consulted for further details as to the applications and limitations of the pressure test.

Picking maturity of different varieties. Considerable information has accumulated regarding the proper picking maturity for specific apple varieties. As examples, and to point out the special problems involved, three leading varieties will be discussed briefly. Detailed information on other varieties commercially important can be obtained from a bulletin by Haller and Magness cited at the end of this chapter.

Delicious. Delicious develops very poor dessert quality if picked in an immature state. On the other hand, it is a common mistake to leave Delicious on the tree too long in an attempt to get high red color development which is extremely important in its marketability. Overmaturity results in poor storage quality.

Elapsed time from full bloom to maturity, as pointed out earlier, is probably the most reliable index for picking Delicious. Studies under widely varying climatic conditions in Washington, Oregon, Illinois, Ohio, Michigan, New York, and Maryland indicate that at least 145 days and preferably 150 days should elapse between full bloom and picking. In other words, harvest should begin at about 145 days and end between 155 and 160 days for satisfactory storage holding.

Delicious may become overmature under long season growing conditions. Under these conditions, the use of the pressure tester may be advisable; apples should be picked before the pressure test drops below 15 or 16 pounds. Water core may develop if Delicious becomes overmature under long-growing season conditions. Another index in determining picking time for Delicious is the fact that the flesh turns yellowish when in proper picking condition. Delicious stores well at 31° to 32° F. At higher temperatures, it may become mealy extremely fast; thus, it is not well suited to common storage and should be placed under refrigeration.

Delicious picked prematurely may develop scald, and in Washington, from 150 to 155 days is recommended from full bloom before picking in order to prevent scald development. When picking must start early, because the crop is large and packing and storage facilities are limited, the early picked apples should not be kept for storage but sold for immediate consumption. Special attention must be given to red sports of Delicious in order not to pick them prematurely.

Stayman Winesap. Relatively late picking is desired with Stayman Winesap in order to get full color development and to avoid scald which develops from harvesting prematurely. Fruit left on the tree too long, however, may develop water core and storage breakdown, and in some seasons, dropping may be serious. The variety requires at least 155 days from full bloom to earliest maturity, and 160 to 170 days for optimum maturity. For best storage, it should not be left on the tree until the pressure test is below 16 pounds. Fruits testing between 15 and 18 pounds have been found satisfactory for storage. The number of days from full bloom is probably the most reliable index of the time to start picking Stayman Winesap. This variety ripens quickly after it is picked and, therefore, should be placed immediately under refrigeration, particularly if picking has been delayed until the fruit has become slightly soft.

McIntosh. McIntosh can be picked somewhat earlier than other fruits because it is almost immune to storage scald. However, the variety should be left on the tree long enough to develop high color and command a premium price; it is not susceptible to water core. The biggest difficulty with McIntosh is that it tends to suddenly drop even before prime picking maturity has been reached. Hoffman has shown that this tendency can be overcome by the application of hormone sprays shortly before harvesting, as described later. This seems to be an important practice with McIntosh because the period elapsing from full bloom to proper picking maturity is often inconsistent. According to Haller and Magness, the minimum days from full bloom to picking maturity is 130; optimum maturity is generally reached between 135 and 140 days. Within these limits, picking may be determined by development of red color and the firmness of the fruit which should not drop below 15 to 14 pounds pressure before picking.

Controlling fruit drop with harvest sprays. Since 1940, many commercial fruit growers have profitably sprayed fruit trees at harvest time in order to control fruit drop on varieties susceptible to dropping. Ingredients used in these sprays are known as hormones; namely, alpha-naphthaleneacetic acid, alpha-naphthaleneacetamide, the sodium salt of alpha-naphthaleneacetic acid, and 2,4-dichlorophenoxyacetic acid. Half strength sprays at five parts per million have proven adequate for most summer apple varieties and under favorable conditions may give effective control of dropping with many fall varieties. Full-strength sprays at ten parts per million may be necessary for fall varieties under many conditions, but generally the small added benefit does not seem to justify the increased expense. Fruit stems must be covered thoroughly with the spray in order to stimulate cell growth in the abscission layer, the cell walls of which normally tend to disintegrate at this time and allow the fruit to break away from the tree. Spraying should be started not later than when about five sound apples have dropped to the ground (McIntosh). However, if these sprays are applied too far in advance of drop, or, are delayed until drop is well underway, little or no effect may be realized. It generally requires one to three days for the spray to become effective; intensity of the effect reaches a peak in five to six days and remains at this level for ten days to two or three weeks, varying with factors such as variety, tree condition and temperature. One application may be sufficient if sprays are properly timed and thoroughly applied. By making two applications, however, with the first a few days ahead of the expected drop, and the second four to six days later, the chances of hitting the fruit at the most receptive period are greatly increased. Addition of one pint to one quart of summer oil in 100 gallons of spray has resulted in slightly increased effectiveness of sprays. Likewise, 0.5 per cent Carbowax added to the spray gives increased effectiveness. Harvest sprays are more effective when applied at temperatures of 80° to 85° F., than when applied at 55° to 60° F. Somewhat higher concentrations at the lower temperatures will increase effectiveness of the spray. Great care should be taken not to allow the fruit to hang on the trees until overripe. Research shows that alpha-naphthaleneacetic acid may slightly increase the rate of ripening of apples and pears.

Recent results have indicated that 2,4-dichlorophenoxyacetic acid (.001 per cent) with one application has a more lasting effect in reducing drop than any other hormone tried to 1945. However, this spray is not quite so effective shortly after applied as other hormones, and may cause leaf and fruit distortions. Twenty-eight days after applied to Winesap apples, 24.9 per cent of the fruit had dropped as compared with 72.9 per cent on the check tree and 68.1 per cent on trees treated with alpha-naphthaleneacetic acid.

HARVESTING THE FRUIT

Considerable care and attention is needed by the manager and foremen during the picking season in order to reduce to a minimum the careless handling of fruit by the laborers. Picking should start with the lower branches of each tree, advancing toward the top in order to reduce dropping of fruit to a minimum. In picking the apple, the thumb is placed beside the "joint" (abscission layer) between the stem and the spur, and the fruit is bent toward the thumb with a quick motion, breaking the joint. The fruit must not be twisted too far or the stem may be pulled out of the apple. This lowers the grade of the fruit and shortens the storage life by allowing disease organisms to enter. Spurs should be damaged as little as possible, and not pulled from the tree because subsequent crops depend upon them. Care should be exercised not to cut the fruit with the finger nails. Each fruit should be *placed carefully* in the bottom of the picking container, and *not dropped*.

The ladder can be raised by thrusting one leg of the ladder into the ground and elevating it sideways. Downward pressure should be exerted while raising it in order to keep the base from slipping. Ladders are carried from place to place in front of the picker, almost perpendicular and tilted slightly back over the head, grasping one rung near the base and another rung with the other hand above the head. The ladder is carefully placed into the tree in order not to bruise the apples, and in such a position that it will fall toward the center of the tree in case it should slip. Most picking accidents can be attributed to improper setting of the ladder.

Adequate field boxes should be dropped near each tree, into which the pickers can carefully place their fruit. Picked fruit should be kept in the shade as much as possible and if left in the orchard a short time, the boxes should be separated slightly for ventilation and covered with canvas or heavy roofing tar paper to exclude rain and sun. If adequate space is available in the packing shed, it is best for a special crew to collect the fruit immediately to prevent excessive accumulation in the orchard. After picking, the fruit must be kept in the coolest place available which is well ventilated in order to arrest respiration and breakdown as much as possible. Apples should never be placed in large bulk piles outside the packing house.

Every hour is precious during the picking season. Adequate efficient labor must be provided to cover the crop before cold weather, possible heavy winds, or before natural excessive dropping of the variety begins. In recent years, the use of harvest sprays has helped relieve this tension to some extent.

THE PACKING HOUSE

Private or co-operative packing. Fruit may be (1) packed in the grower's own packing house, or (2) it may be hauled to a community or co-operative packing house.

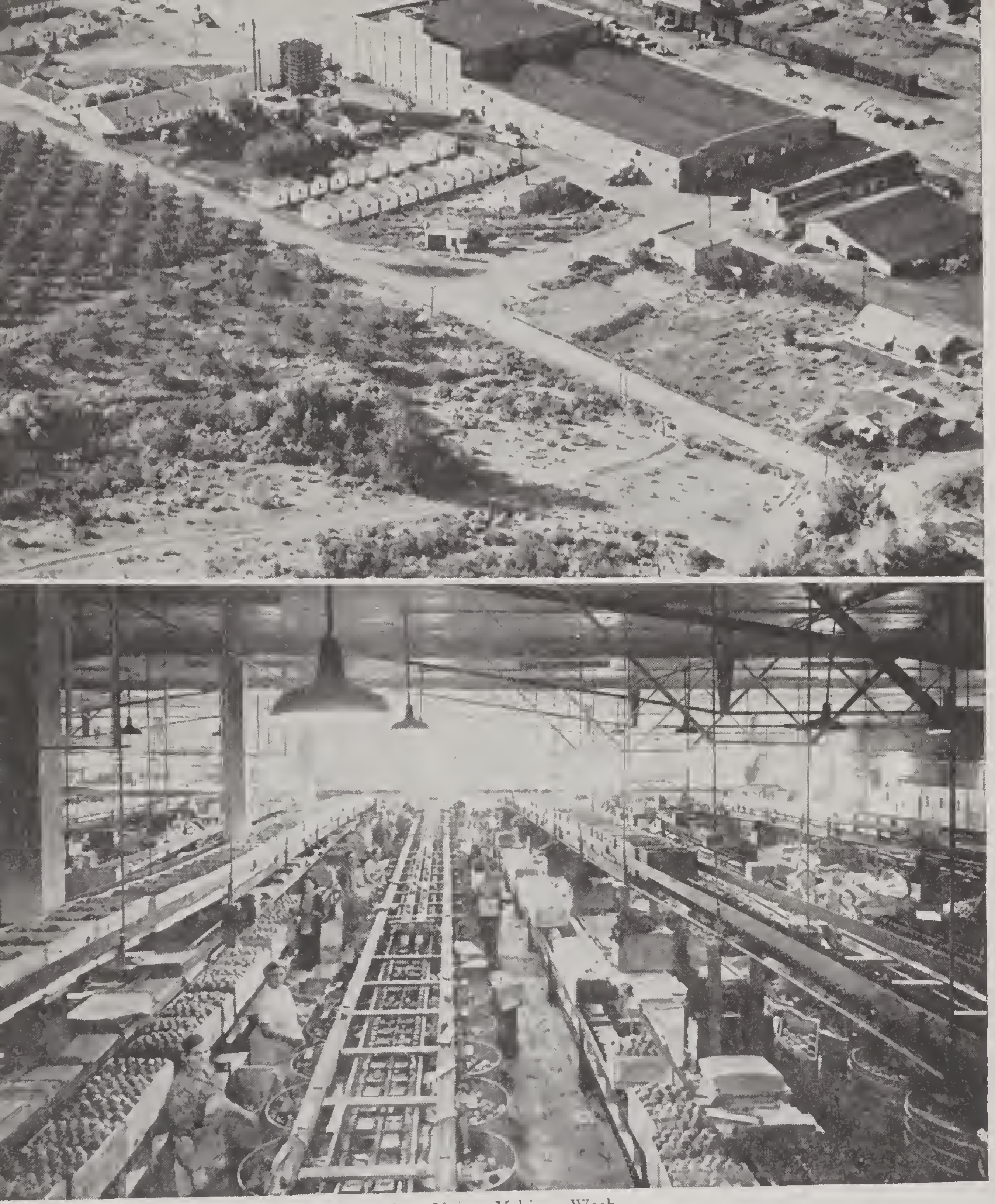
(1) Many of the growers, especially in the Middlewest and East, own their packing house and storage. Under these conditions, the grower can hire his workmen on a year-round basis and work may go on in all kinds of weather. These grower-owned packing houses are more or less a necessity in orchards which are scattered, and the quantity of fruit harvested within a region hardly justifies a co-operative packing house.

(2) Community packing houses operated co-operatively or as a private enterprise, are used extensively in the West for all types of fruit (Figure 112). In the East, they are used only in sections where the apple industry is more or less concentrated. Co-operative packing is conducive to a uniform grade and pack which is highly desirable from a marketing viewpoint. Also, there are important economies in operation and lower costs per package for grading, sizing, and packing because of a large volume of fruit handled, good machinery and equipment, and well-trained and supervised personnel. The grower devotes his entire attention to harvesting and hauling his fruit to the community packing house. The co-operative usually assumes full responsibility for further handling of the fruit. This arrangement gives the grower more time to grow a larger acreage of fruit than might otherwise be possible. The many advantages of co-operative packing houses have been pointed out in Chapter II.

The general procedure for operating community packing houses is approximately as follows: The grower delivers tree-run fruit to the packing house. He is given a receipt for the number of containers and varieties delivered. Each grower's fruit is kept separately and labeled, then washed, graded, sized, and packed separately. The number of packages of the various grades and sizes, and the number of pounds of unclassified or culled fruits are entered into the association's books, after which the grower's fruit loses its identity. The culls are run through an adjoining processing plant and made into vinegar, cider, apple juice, apple concentrate, candy, or similar by-products. Growers are paid a flat rate for culls. In some cases, instead of running each grower's fruit separately, a few bushels are carefully graded by hand and the relative proportion of grades and sizes are then estimated for the entire crop. In the long run, this latter method is more convenient and saves considerable time.

Packed fruit is usually sold by the association. Returns to the grower are made on the basis of a pool extending through all or part of a season, prices varying with each variety, grade, and size. The association deducts packing charges, depreciation of building and equipment, insurance, and interest on investments. These costs are pro-rated on the basis of the quantity of fruit brought to the packing house by each grower. By this means, the accounts cannot be completely cleared until the season is over, but it is customary for advances in cash to be made to the grower in the meantime.

Requirements of a good packing house. The site for a community packing house should best be located next to a railroad siding. Privately owned packing houses are more accessible when located near the center of the



R. W. Staples, Yakima County Hort. Union, Yakima, Wash.

Figure 112. (Top) Apple storage and packing plant in the Yakima Valley, Washington. Packing house is at the right with rounded roof. The storage plant for over 580,000 boxes is at the left of packing house. Cabins for seasonal help are shown in the foreground. (Bottom) Inside view of the packing house in which a battery of five rotary-bin weight graders are being used. Co-operative houses such as this are capable of efficiently handling thousands of apple boxes a day at a relatively low cost per box.

orchard if the land is relatively level; if the orchard is hilly, the packing house should be located where there is a minimum of uphill hauling. From the standpoint of roadside trade, if available, it might be well to locate it on a heavily traveled road.

Requirements for a good packing house are as follows: (1) adequate space for receiving fruit, thus making it possible to accumulate a supply to pack out during bad weather when picking must be stopped, (2) adequate over-all lighting above the sizing, washing, and packing equipment; light may be provided by electricity or by sky windows supplemented with electricity for dull days, (3) adequate storage space for a part of the season's supply of packages, (4) conveying equipment for transporting culls out of the way and moving empty and filled packages to and from the packing tables, and (5) an excess of space for holding packed fruit until it can be loaded into trucks or carloads, or transported to storage. An excess of space is recommended because the railroad may not be able to furnish shipping cars in regular succession as needed. Suitable space should be available next to the packing house for later additions and extensions, particularly of cold storage space.

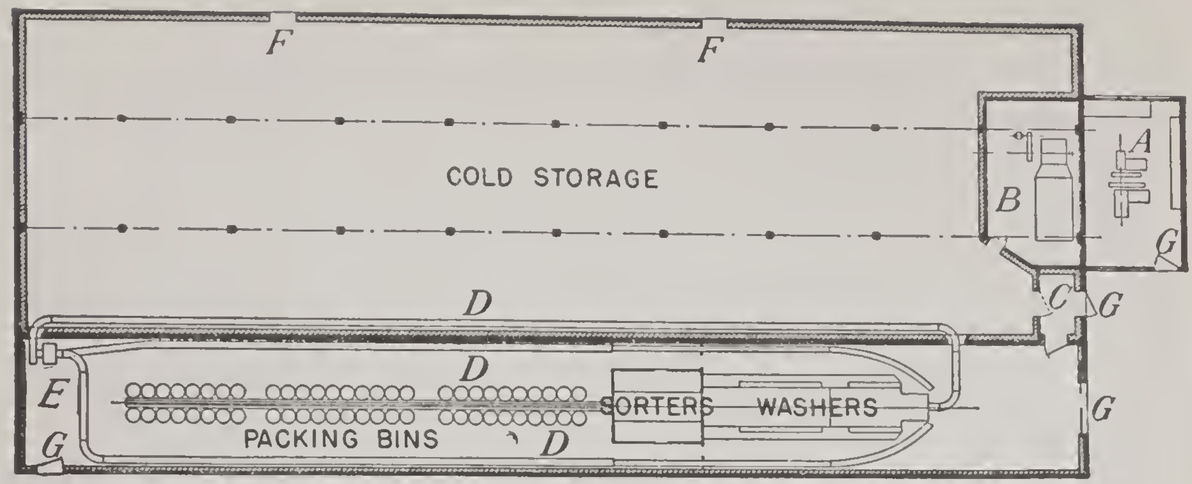
A good arrangement is for the first floor to be used for accepting the incoming fruit, and for washing, grading, sizing, and packing. The loft is used for unassembled and assembled packages and supplies, and the basement is equipped for storage. Such a house could well be built on a slope so that the first floor and basement could both be at ground level. Also, this will permit ventilation in the basement storage room which is highly important in case of common storage. Rather than a loft, some growers keep packages and supplies in a side room and place skylights in the ceiling of the packing house to reduce the cost of electric lighting. The separate assemblage and storage shed for packages might well be slightly higher than the first floor so packages can be sent by gravity to the packing house on chutes.

A suggested floor plan for packing and storing apples from a medium-sized orchard is shown in Figure 113. The same general arrangement could be used with modifications on a larger or smaller scale.

Tile walks with concrete base and floors are commonly used in packing house-storage combinations. Tile is good insulation, fire proof, durable, and fairly economical. Brick is also popular when available near by.

Packing house operations. After the fruit reaches the packing house, it may undergo all or most of the following steps in the order listed: (1) *washing* to remove spray residues, (2) *sorting* into two or three grades, (3) *waxing* to increase storage life and reduce shriveling of varieties such as Golden Delicious, (4) mechanically *sizing* each grade into several sizes, and (5) *packing* into containers. The equipment and procedure in carrying out each of these steps will be discussed separately and in the above order.

Spray residue removal. A film of spray residue tends to accumulate on apples as the spray season progresses. Before these apples can undergo interstate shipment, Federal rulings require that the arsenic, as arsenic trioxide, be



W. V. Hukill and Edwin Smith, U.S.D.A.

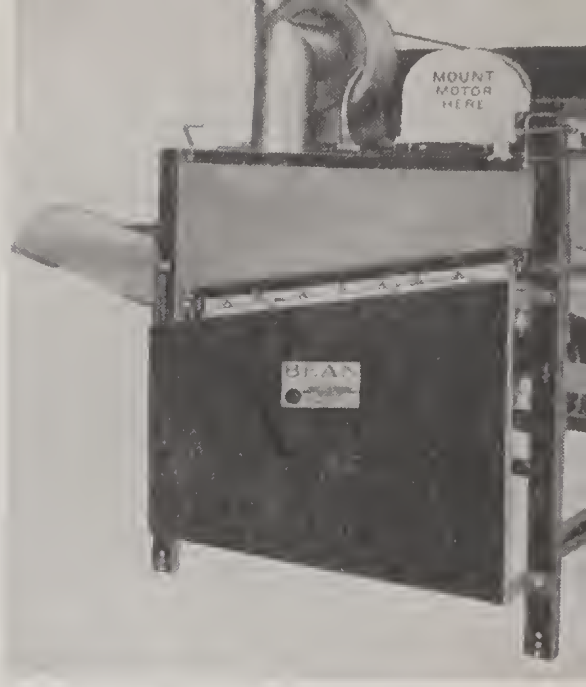
Figure 113. Efficient arrangement of packing house, 20 by 166 feet, and cold storage, 50 by 166 feet, with refrigerated basement, designed for medium-sized orchard. *A*, outside compressor room, 16 by 28 feet; *B*, brine-spray and fan room; *C*, air lock to save refrigeration from open outside doors; *D*, fruit conveyor system; *E*, packing-lidding press; *F*, ports for receiving or delivering fruit; and *G*, outside doors.

reduced per pound of fruit to .025 grain, fluorine to .02 grain, DDT to .049 (tentative), and lead to .05 grain. Although there is little or no experimental evidence to show that the amount of arsenic or DDT on fruit at the time of harvest is detrimental to human health, nevertheless the Federal government deems these rulings necessary and the orchardist must comply with them. Many large apple growers are using washing machines, however, not only to remove spray residues, but to clean the fruit and give it an attractive appearance in the package.

The amount of residue remaining on the fruit at harvest varies with: (1) the number of sprays applied, (2) date of last spray, (3) presence or absence of oil in the spray, (4) summer temperatures which affect natural wax formation by the fruit, and (5) the amount of rain.

In some sections, brushing machines (Figure 114) are sufficiently effective in reducing the spray residues below the specified maximum amounts. Brushers also have the added value of giving the fruit an attractive luster. However, they leave a certain amount of residue around the stem and calyx ends of the fruit, and for this reason are not too effective in removing large quantities of residue, in which case washing is necessary.

There are several types of washing machines on the market. The general principle of operation is more or less the same as that described in Figure 115. The fruit is gently emptied on the rubber feed belt at the right, leaves and trash sift through to the floor or a trap, and the fruit moves into the machine by a wooden "scalloped walkover" or shuffleboard conveyor. Instead of this type conveyor, some washing machines have alternating brushes turning in opposite directions, one set moving 160 r.p.m. in the direction of the moving fruit, and the other set moving 60 r.p.m. in the opposite direction. Thus, the fruit moves slowly forward through the machine, but in so doing, it is twisted, turned, and thoroughly brushed while the washing solution is flooded upon it from above. The brush type of washer is somewhat more effective in removing residues than the shuffleboard-flood type shown in Figure 115, although in most cases the latter type is quite satisfactory and somewhat more economical in cost and maintenance. After the fruit has been subjected to the washing solution, it is then carried to the clear-water rinse section, thence to the driers, and on to the sorting or grading table.

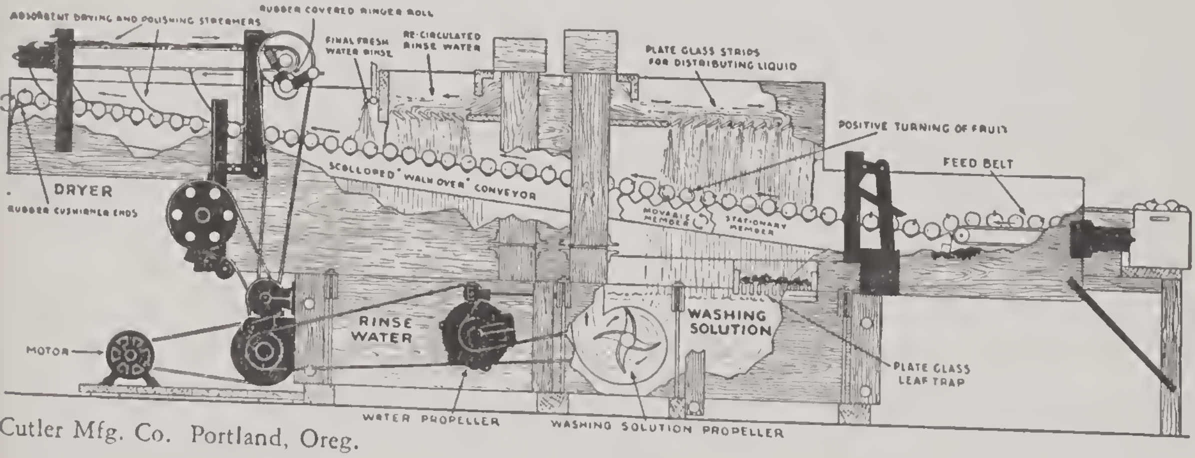


John Bean Mfg. Co., Lansing, Mich.

Figure 114. Fruit brushing machines may be substituted for washers if the apples contain relatively low deposits of spray chemicals. Some growers use brushes, regardless of need for spray residue removal to give the apples a bright luster. The capacity is 1000 to 3000 bushels for ten-hour day.

The washing solution consists of about 1 per cent solution of hydrochloric acid prepared by adding three gallons of commercial hydrochloric acid to 97 gallons of water. The tank is first filled about half full of water and kept well agitated by running the motor while adding the acid in order to prevent the acid from settling to the bottom. The apples, while passing through the machine remain under the acid washing solution about one and one-half to three minutes. If they remain longer than five minutes, acid injury is likely to result. It is important to have an abundance of fresh rinse water (two to three gallons per bushel of fruit), if acid burning and contamination by mold spores is to be avoided. The rinse solution should be changed frequently enough to keep it relatively free of acid. If fresh water is limited, periodically add two pounds slacked lime to each 50 gallons of rinse water to keep it alkaline.

The acid washing solution is more effective when heated to between 75 and 100° F. by thermostatically controlled steam or an electric heating unit. Temperatures should not exceed 100° F. because of danger of acid burning. Wetting agents are sometimes added to the acid solution to increase effective-


ABSORBENT DRYING AND POLISHING STREAMERS
RUBBER COVERED RINGER ROLL
FINAL FRESH WATER RINSE
RE-CIRCULATED RINSE WATER
PLATE GLASS STRIPS FOR DISTRIBUTING LIQUID
POSITIVE TURNING OF FRUIT
FEED BELT
DRYER
RUBBER CUSHIONED ENDS
SCALLOPED "WALK OVER" CONVEYOR
MOVABLE MEMBER
STATIONARY MEMBER
RINSE WATER
WASHING SOLUTION
MOTOR
PLATE GLASS LEAF TRAP
WATER PROPELLER
WASHING SOLUTION PROPELLER

Cutler Mfg. Co. Portland, Oreg.

Figure 115. A flood-type fruit washer and drier with a shuffleboard conveyor to move the fruit along. A tandem washing machine consists essentially of two of the above machines in series, using two types of washing solutions with two rinses for removing heavy deposits of spray residue.

ness of cleansing. Among wetting agents available are Grasselli, W. A. No. 2, Vatsol, Lethalate, Oronite, and Nekal B.

Double or tandem washing machines are in use in the West where a heavy spray residue is built up on the apples and where presence of oil in the sprays makes the residue more difficult to remove. Also, some apples, such as Winesap, tend to develop considerable natural wax on the skin and make it necessary to use a sodium silicate solution, 6 per cent, in the first washing machine, followed by a water rinse, and then the usual hydrochloric acid wash in the second machine, followed by another rinse.

Some *flotation*-type washers (usually homemade) are in use in small orchards, but, as a whole, they have almost disappeared. The apples are floated through an open trough of acid solution, and then conveyed over a partition into the rinse bath before going to the sorting table.

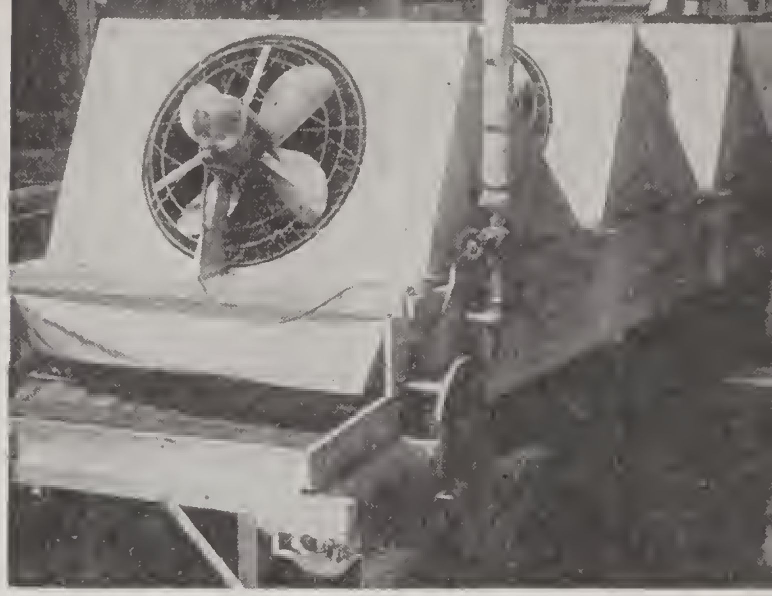
WAXING APPLES

Some apple varieties, such as Grimes Golden and Golden Delicious, lose moisture and shrivel more rapidly after picking than other varieties. Sometimes this is due to large cracks occurring in the cuticle, and with some varieties it is correlated with the amount of protective wax formed naturally over the skin. Experiments have shown that shriveling can be reduced from 30 to 50 per cent in a six-month storage period by applying Brytene wax No. 489-AM, one part in three parts of water. While the wax film inhibits moisture loss, it is apparently porous enough to permit almost normal interchange of gases because foul flavors and odors do not seem to develop by the end of the storage season. Waxing of apples is now being used on a commercial basis in the West and to some extent in the East (Figure 116).

It is the usual practice of most growers to hold yellow varieties of apples in the packing house for about ten to fourteen days after picking in order to improve coloring. Obviously, this results in some sacrifice in their storage life, as compared with apples placed immediately in storage. However, fruit so treated can be waxed at the end of this preripening period and held in storage equally as long as fruits placed immediately in storage from the field. Also, this combined treatment has been found effective in reducing scald on Grimes Golden; whereas, fruit of this variety brought from the field, waxed, and immediately placed in storage tends to develop significantly more scald.

Van Doren has described a homemade apple waxing machine which can be constructed from readily available materials at a cost less than $300 (1944). His pilot model had a capacity of 300 to 600 bushels per day, depending upon surrounding temperatures (the fruit dried more slowly on cool days). One gallon of wax at $2.50 per gallon when diluted one to three, waxed over 200 bushels of fruit. Cost of waxing amounted to about three cents per bushel, whereas commercial waxing in the West is calculated at about five cents per bushel. ✓

Waxing is a promising commercial practice for prolonging the life of all apple varieties, as well as many other fruits. In addition, waxed apples stand up longer on the sales counter and exhibit an attractive gloss.



Grabill Mfg. Co., Woodstock, Va.

Figure 116. Commercial apple-waxing equipment in use at the H. F. Byrd packing hause, Berryville, Virginia. Waxer is lacated after sarting table and befare fruits are sized. Apples are sprayed with wax solutian at far end af waxer befare passing thraugh the faur drying chambers and anto belt in faregraund. Driers are equipped with small steam-heated cails thraugh which a draft is created by high-speed fans.

Grades and grading equipment. Grade refers to the exterior quality of the apple. This includes color, condition as to firmness and soundness, and freedom from blemishes. The U. S. Department of Agriculture standards for apples provides for and defines the following grades: United States Fancy, United States Number 1, United States Commercial, United States Number 1 Early, United States Utility, United States Utility Early, Combination grades, United States Hail, and Unclassified. Some states recognize an Extra Fancy grade which is the highest degree of perfection in color, condition, and uniformity in shape. The only difference between U. S. Fancy and U. S. Number 1 is the amount of color; the difference between U. S. Number 1 and U. S. Commercial is essentially color with somewhat more tolerance to blemishes in the latter grade.

The grade requirements of U. S. Fancy are given only as an example of the type of specifications the grader must meet in making this pack.

"*U. S. Fancy* shall consist of apples of one variety which are mature but not overripe, carefully hand picked, cleaned, fairly well formed; free from decay, internal browning, scald, freezing injury, broken skins and bruises (except those incident to proper handling and packing), and visible water core. The apples shall also be free from damage caused by russeting, sunburn, spray burn, limb rub, hail, drought spot, scars, disease, insects, or mechanical or other means. Each apple of this grade shall have the amount of color specified hereinafter for the variety (e.g at least 33 per cent of surface of Delicious must be red)."

The Federal grades are being adopted by many states and more detailed information on grade requirements can be secured either from Grades and Standards for Fruits and Vegetables, U. S. Department of Agriculture, or from the local state department of agriculture. Many of the states have special grading and branding laws. The grower also can obtain this information through his local state department of agriculture. It is highly important that the graders thoroughly know the requirements for the grades which they are packing and that the grading be thoroughly supervised by a reliable foreman to see that the job is done correctly. In fact, special supervision is required at all phases of the grading, sizing, and packing in order to avoid unnecessary bruising of the fruit and consequent price discount.

Boxed apples in the West are usually graded into Extra Fancy, Fancy, and C grades, each separated into several sizes. Apples packed in baskets normally have about two grades with several different sizes in each grade.

Grading Procedure. Apple sorting tables are usually equipped with wood rollers which are spirally wound with sash cord. Sorting tables are manufactured with four, eight, ten, or twelve roll units, the rolls being divided equally on both sides of the table, except that the four-roll unit has all rolls located at the right side. In the center of the sorting table is a four-inch cotton belt for carrying cull fruit back to a dump container on the side.

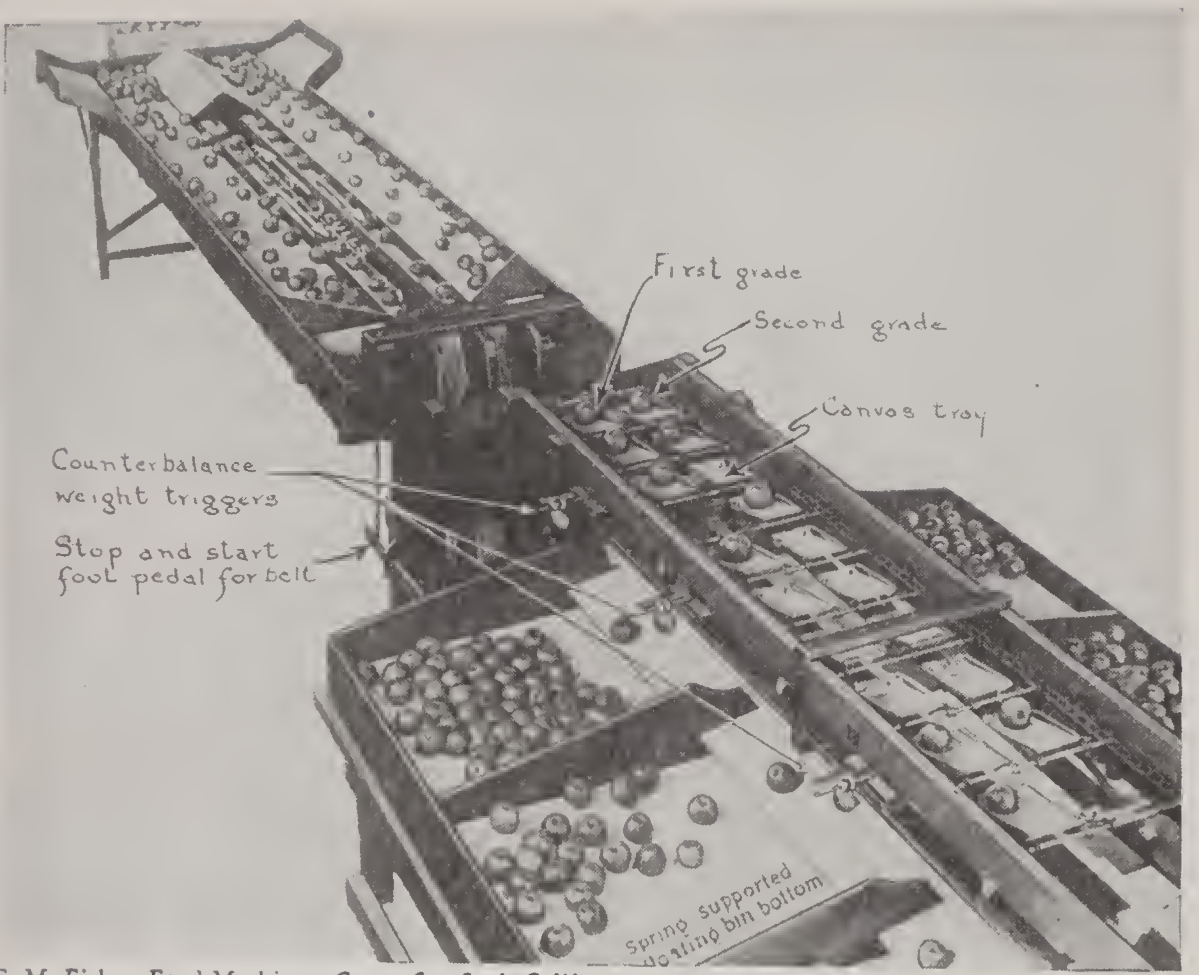
The spiral rollers revolve the fruit slowly while it is conveyed forward to the sizers, exposing the entire surface of each apple many times while it passes before the sorter. This makes it easy for the sorters to detect and pick out culls and low-grade fruit. The fruit which is picked up by the sorters is shifted to various belts according to grade. The grade making up the largest quantity of fruit is not touched by the sorters, but continues through a shunt which automatically diverts it to the end section of the sizer, thus effecting about a 25 per cent saving in sorting costs.

A control mechanism is provided for regulating the speed of sorting rollers on each side of the table. The lever will either start and stop the spiral rollers or vary their speed while the machine is in operation. This feature enables the head sorter to regulate the speed to conform with the condition of the fruit and the amount of handling by hand which is necessary. Most machines have two separate return belts from the packing bins on which packers can place offgrade fruit to be returned to the sorters for regrading.

Sizing and sizing equipment. Size refers to the transverse diameter of the apple at the point of its greatest circumference; size varies with the variety and growing conditions. Any size of apple may fall into any grade, and vice versa. A two and one-quarter-inch Jonathan and a three and one-half-inch McIntosh may be equally high in grade.

The variation within a given size must not be more than one-quarter inch in transverse diameter when the number of fruits as well as size are marked on the container. When the number of fruits in the container is not indicated, the minimum size of the fruit is all that is required, as for example "2¼-inch minimum." With uniform size and grade designations, the package looks much better, brings a higher return, and the buyer knows what to expect without opening and checking the package, provided the U. S. or state grades are mandatory and enforced where the fruit was packed. Unfortunately, there are a number of important fruit states where the sizes and grades are still not enforced too well.

After the fruit has been sorted or graded, as described previously, each grade is conveyed separately by belts to the sizing machinery. The sizing machine may be small or quite large, depending upon the amount of fruit to be handled daily. Large capacity power driven units may handle as much


First grade
Second grade
Canvas tray
Counterbalance weight triggers
Stop and start foot pedal for belt
Spring supported floating bin bottom

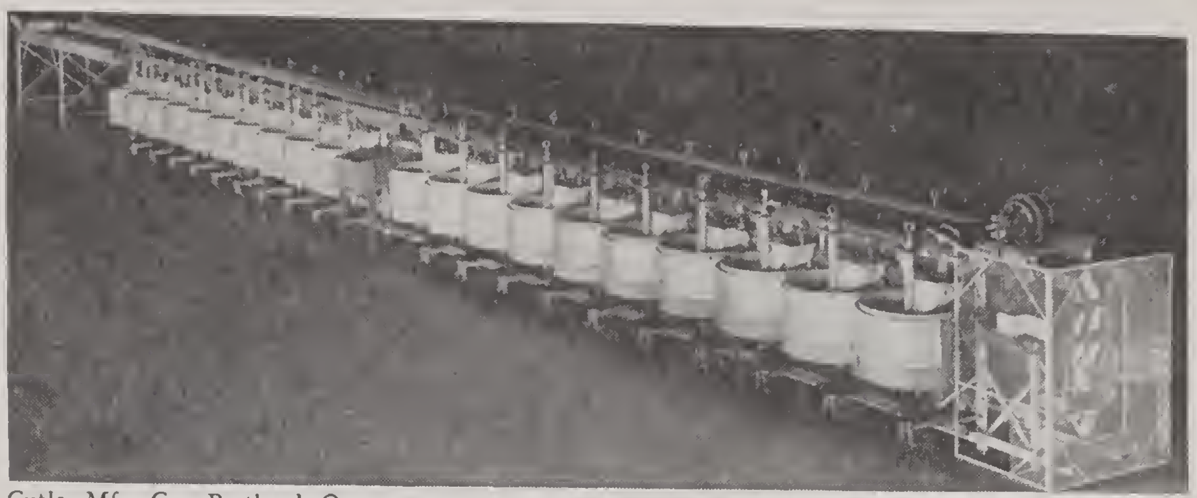
F. M. Eicher, Food Machinery Corp., San José, Calif.

Figure 117. Apple and pear sarting table is shown at rear, a part af sizing machine in fareground. If a washing machine is used, the fruit-receiving "flare" at far end is adjusted ta carefully receive the fruit direct fram washer. Machine is equipped ta accammadate twa grades. Nate that each fruit must be picked up by sarters, examined, and placed an a belt accarding ta grade ar quality. This equipment is suited ta grading add-shaped fruits, and varieties that are easily bruised.

as 100 to 150 or more boxes per hour. Several batteries of these large units may be employed in co-operative packing houses. The smaller capacity machines may handle 45 or less boxes an hour for an individual grower. Most growers purchase or adapt their machines to handle two or three grades of several different sizes in each grade.

The sizing may be done mechanically *by weight* or *by size*. The sizing principle involves the use of a rubber or chain belt, or oscillating cups, perforated with the respective sizes through which the apples gently drop onto canvas aprons, and then roll into padded bins. Another system is the use of revolving rubber-tired wheels which are adjusted at different heights corresponding to the size of fruit they are designated to brush off the belt into the respective bins. These sizers have the advantage of sizing the largest fruit first, thus handling the best fruit the least with less opportunity for mechanical bruises.

The larger sizing equipment usually does the job by weight. Each fruit rides in a small canvas tray (Figure 117) along a track until it reaches a point where its weight slightly overbalances a spring-tension trigger, or a trigger which is counter balanced by a lead bead bag or another apple of the



Cutler Mfg. Co., Portland, Oreg.

Figure 118. The rotary-bin graders size by weight and are used exclusively for hand packing in wooden boxes or fiberboard cartons. Apples are graded and diverted into bins according to weight, and they are gently dropped on a canvas catcher which lowers them into bins. Bins will hold four to five boxes of fruit. Adjustable floating spring bottoms in the bins maintain the fruit at convenient level for packer. Model is suitable for two or three grades with maximum of ten sizes in each grade. Grader capacity is 100 to 150 boxes per hour, accommodating ten sorters, and operated with a one and one-half h.p. motor.

desired size. At this point the weight of the apple trips the trigger and it gently drops into a padded bin. The size of apples that the trigger will drop can be regulated by adjusting the spring tension, the amount of beads in the bag, or the size of the counter apple.

The bins in which the fruit accumulates before being packed may be either stationary or rotary. The stationary bins (Figure 117) have been used for many years for packing baskets, boxes, and barrels. In recent years, however, the rotary bin (Figure 118) has increased in popularity rapidly for special hand packing of boxes and fiberboard cartons. The bins have a floating bottom which maintains the fruit at a specific level at all times and within easy reach of the packer. The bin rotates slowly and gives the packer opportunity to choose each apple; the rotating also facilitates equal distribution of fruit in the bin.

Packing apples. Under ideal conditions, apples should be packed and stored or shipped immediately after picked. If the fruit is handled when more or less hard immediately after picking, there is less danger of bruising and of subsequent bluemold infection; the sooner oiled paper is mixed among apple varieties susceptible to scald, the less the development of the disease. Another advantage of immediate packing is that it gives an opportunity to sort out and immediately eliminate the culls which are not only a source of infection to the quality fruit, but may take up valuable space in the packing shed or storage.

Under practical conditions, it is usually necessary to keep some of the crop out of storage for a few days to a few weeks before it can be packed either for storage or for market. In northern states this can be done fairly well with the cool autumn weather. With some varieties susceptible to bitter pit, as Northern Spy, it seems advisable to delay packing for a month to six

R. R. Pailthorp, U.S.D.A.

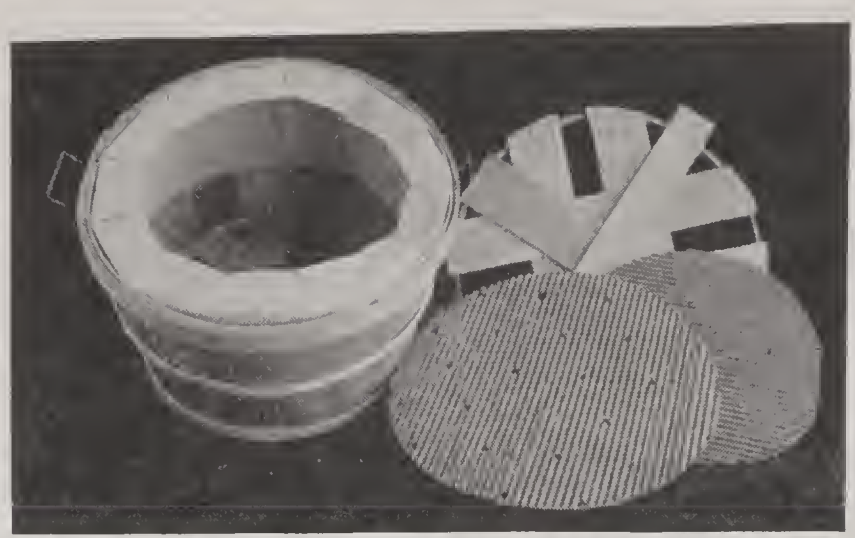


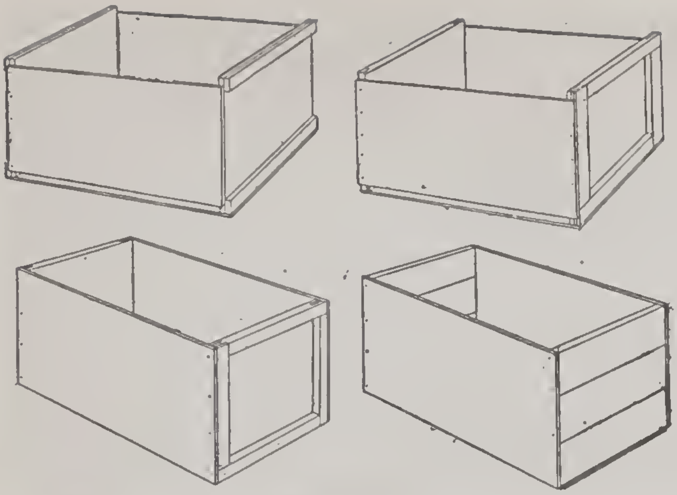
Figure 119. The straight-sided, flat-bottom bushel basket is popular; it is rigid and stout.

weeks to permit the disease to develop, and then eliminate affected fruit over the grading tables. If private storage space is available, some growers place the apples directly in storage, and pack them out as soon as possible. This practice might be satisfactory for the orchardist growing high-grade fruit, but expensive for the orchardist with low-grade fruit, who pays for refrigerating a large quantity of culls which later will be discarded.

The effect of delay in storage. Temperature has a profound effect on the ripening of apples. For example, softening of fruit proceeds about twice as fast at 70° F. as at 50° F., and at 50° it is almost twice as fast as at 40°, while at the latter temperature, it is fully twice as fast as at 32°. About 25 per cent longer time is required for fruit to ripen at 30° than at 32°. Thus, it is clearly evident that the sooner fruit can be placed in storage at 32° F., the longer it will keep in top-quality condition. Every effort within reasonable practical limits should be exercised to prevent the fruit from remaining in the orchard or in the packing shed longer than absolutely necessary.

Types of packages. Types of packages used for marketing apples have been ever-changing. In the 1920's, the barrel was almost a universal package in the Eastern areas. However, except for an export container, the barrel has been almost entirely displaced by smaller packages which display better and are easier to handle. For this reason, the barrel will not be further discussed here. The wooden box has been used almost entirely in the northwest apple section, and its use has spread to the East where it is now widely employed.

The continuous-stave bushel basket followed the barrel in the East, but this type of container was unsatisfactory because it was largely a jumble pack, the lid tended to cut the apples, and the springy bottom and sides did not protect the fruit when the containers were stacked. This container was followed by the "tub" basket, as shown in Figure 119, which is used today to some extent for export and is the most popular bushel container because it protects the fruit in stacking and in shipment. The bottom is removable on some types, which enables the packer to set the basket upside down and put in the face first on the sealed lid, then fill the basket and fasten the bottom on last. The highest grade fruit is often packed in baskets. However,



National Wooden Box Association, Washington, D. C.

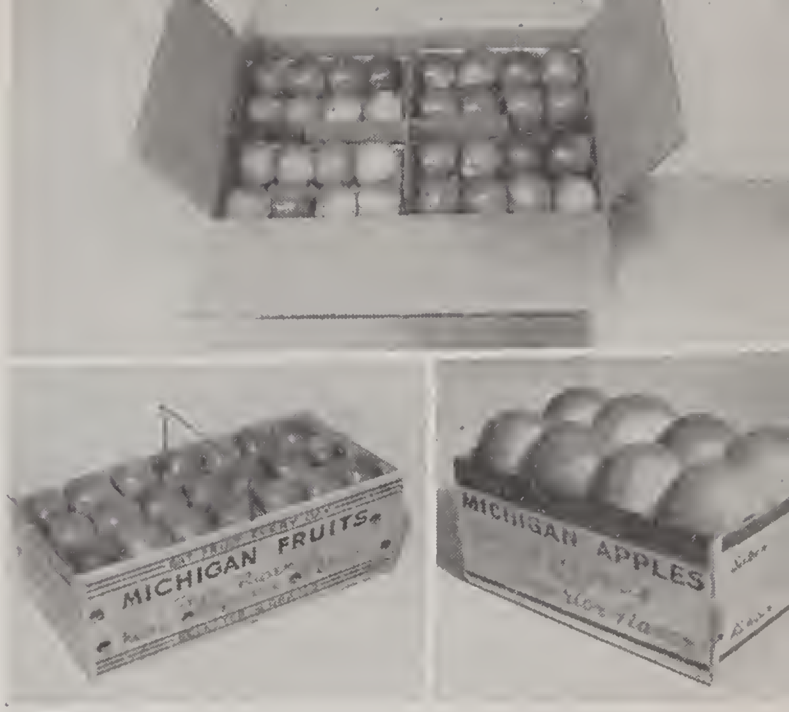
Figure 120. The upper two types of apple boxes are designed for flat pack and are frequently used in the East. The lower boxes are designed for bulge pack. Specifications for boxes are (top left) cleated-end style box, containing 1⅕ bushels (2618 cu. in.); (top right) a panel-end style box, containing 1⅕ bushels; (bottom left) a panel-end style box, containing about 1 bushel (2174 cu. in.); and (bottom right) a solid-end style box, containing 1 bushel.

for the most part, baskets of the one-half- or one-bushel size are used for U.S. Number 1 and lower grades of fruit.

The *box* type of package is increasing in popularity in the East more than other types of packages. In 1939 more than 85 per cent of the total commercial apple crop of New England was marketed in a crate which has the dimensions of 17 by 14 by 11 inches inside measurements, holding one and one-fifth bushels of apples (Figure 120). When shipped by refrigeration car, this box is modified with the dimensions of 16 by 13⅝ by 12 inches. It is satisfactory for export trade provided it is held together by slats and provided with a cushion top. However, this container was developed primarily as jumble pack to protect tender varieties such as McIntosh, but somewhat arbitrary dimensions were set up, and as a result boxes of many shapes and sizes appeared. This caused confusion and eventually resulted in the selection of a generally agreed upon standard-size eastern box holding one and one-eighth bushels (1944).

The highly popular Western apple box has the standard dimensions of 10½ by 11½ by 18 inches inside measurements. It holds 2173.5 cu. in., or 23.08 cu. in. in excess of the U. S. standard bushel of 2150.42 cu. in. A special style, 10 by 11 by 20 inches is sometimes employed in the East. Both are used for export as well as interstate trade. The box is made up of one-piece ends about three-quarter-inch thick, tops and bottoms of two pieces, one-quarter-inch thick, and one-piece sides about three-eighths-inch thick. It is essential that the tops and bottoms be thin enough to spring when the box is packed, thus making a slight bulge which insures a tight pack. Boxes are usually bought flat and nailed together at the packing shed. After packing, they are laid on their sides.

Several types of fiberboard containers are in use and may be packed similarly to a standard box. Most fiberboard boxes are designed with inside wooden support slats to eliminate bruising and flimsiness when packed. Other styles have egg-crate type cells for individual apples. This type of fiberboard container provides maximum protection against bruising, but many different sizes and shapes must be manufactured to accommodate different sizes and shapes of the varieties. Because of this, they are difficult to load satisfactorily in trucks and refrigerator cars for shipment, or to economically utilize all space in the cold storage. Objection is sometimes raised against corrugated fiberboard because it is good insulating material, and consequently, it takes longer to cool the fruit, especially when sealed tightly. On the other hand, it takes longer for cooled fruit to warm in these containers. Another objection given by some growers is the fact that fiberboard boxes tend to moisten in storage and hold the fruit less rigidly after several months of storage. It is at this time after the fruit has ripened and become somewhat soft when maximum protection is paramount.



J. A. McCormic, Fruit and Produce Packing, Indianapolis

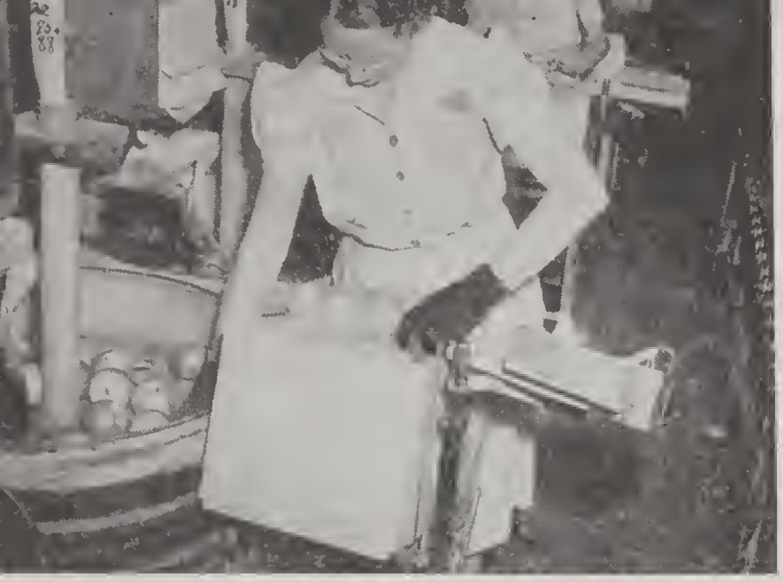
Figure 121. Small corrugated consumer cartons, alone or grouped in large containers, are popular for chain-store trade. The housewife can carry and place them conveniently in the refrigerator.

Colored mesh bags containing a few to several pounds of fruit have been used on local markets with fair success, but they are not a high-class container for several reasons.

In the choice of containers, there are several factors to consider. Some varieties, such as McIntosh, are more tender than others and, therefore, demand a type of package which causes as little bruising as possible. In some seasons, the general crop is of higher quality than other seasons. Thus, it may justify a larger proportion of high quality containers. The grower should not be misled by the presence of a minor quantity of highly colored specimens in his crop. To pack these into the higher grades may so reduce the appearance of the remainder of the crop as to make the project uneconomical.

When the general crop situation is short, the proportion of fruit packed in closed high-grade packages might be increased to an advantage. But when the crop is average or heavy, only the better fruit is likely to pay the attendant cost of better packages. If a considerable portion of the crop is to be sold locally by weekly delivery in large market and chain stores, it might seem advisable to use small cartons containing, for example, one-half, one, or two dozen apples (Figure 121). Co-operation between grower and dealer has enabled the grower, in some cases, to use these display cartons over and over while the dealer transfers the fruit to less expensive paper bags for each sale.

It is well for the grower to study the market preferences and make every effort to give the dealers and consumers the container and pack they like. It is too expensive and laborious a process to try to change the nature of the demand in order to suit the grower's own desires. It is true that some growers in the East contend that box packing is too slow and costly and that the fruit of Eastern orchards is not sufficiently uniform in size and color to box.



C. E. Chase, Washington State Apple Adv. Commission

Figure 122. Northern Spy apples being packed in boxes from rotary bins. Note packer is wearing gloves to avoid fingernail cuts; a rubber cap is on second finger, left hand, for grasping paper. She is packer No. 22 working at two bins, packing boxes with 80 and 88 fruits.

However, much of the fruit that is contended to be unsuitable for boxing because of lack of uniformity, inferior color, and other reasons, is no longer profitable to grow for any purpose. The public has far passed the stage where such fruit is acceptable to it, except in the form of by-products. Growers of this type of fruit must either change their practices or be forced out of the business.

Packing in boxes. Only the best grades of apples are packed in boxes; namely, Extra Fancy, Fancy, and C grade or U. S. Number 1. The general box-packing procedure is as follows: The empty boxes come to the packers in reaching distance on a gravity conveyor. A box is placed upon a small stand, as shown in Figure 122, at a convenient height for the specific packer. Each stand is equipped with a hod containing wrapping paper for the apples. The paper is 12- or 14-pound weight and glazed on the surface away from the fruit. Wrapped apples pack easily, are protected from decay and injury, and give an attractive package on the market. The wrapping paper size varies with size of fruit. Largest apples are wrapped with 14 by 14 inch paper; apples which run 64 to 80 to the box require 11 by 11 inch paper; 88 to 113 require 10 by 10 inch paper; 125 to 180, 9 by 9 inches; and for smaller sizes, 8 by 8 inches. Small apples are sometimes packed without wrappers. The paper may be stamped with an attractive brand or trademark. Paper impregnated with a special oil is employed for varieties which tend to develop storage scald. Gloves for the packers are preferred to prevent fingernail marks on the fruit. Second finger on the left glove is removed in order that a rubber cap can be used on that finger to facilitate grabbing the paper.

Two lining papers are placed in the boxes before packing starts, so that they overlap on the bottom with a slight fold along the bottom sides to afford slack which will be taken up without tearing when the cover is nailed in place. After the box is packed, the top edges are folded over each other. Blue paper is used for Extra fancy, pink for Fancy, and white for C grade of 20-pound sulfide or 23-pound news grade, each lining sheet 17½ by 26 inches.

Although no two persons wrap in exactly the same manner, the general procedure is shown in Figures 123, 124. It will be noted that there are several movements for the wrapping of each apple and, therefore, the procedure should be studied carefully and practiced in order to eliminate all unnecessary twists or turns. The following procedure as outlined in the U. S. Department of Agriculture Farmers' Bulletin No. 1457 clarifies the procedure.

"The wraps are in the paper holder, glazed side up. A rubber finger stall is worn on the forefinger (or second finger) of the left hand, as by its use single wraps are picked easily. The wrap is picked up with the left hand, one corner pointing toward the packer, the center of the wrap in the center of the palm. At the same time an apple is picked up with the right hand.

"The apple is thrown into the wrap with some force in order to jerk up the edges of the wrap around the apple. The apple strikes on its cheek in the center of the wrap, with its stem end pointing midway between the thumb and index finger. As the apple is caught, the thumb and fingers of the left hand are closed about the apple, forming a cup, and remain in this cupped position throughout the wrapping process. As the apple is thrown, the right hand advances toward the blossom end of the fruit with fingers together and thumb extended at nearly right angles to fingers. The index finger is up and the little finger is down. The lower corners of the wrap are brushed closely over the apple with the thumb and forefinger of the right hand, bringing all corners of the wrap tightly together at the top, except the corner between the thumb and forefinger of the left hand.

"Now, holding the apple tightly within the wrap with the thumb and forefinger of the right hand, both wrists are twisted toward the right. The apple turns within the cup formed by the left hand, the fingers of the left hand moving between the apple and the fingers of the right. The hands are turned completely over, until the back of the left is upward and the back of the right is downward.

"The apple is now held in the cup formed by the left hand with its stem pointing between the second and third fingers and is placed in the box with the tails of the paper downward, while the right hand reaches for another apple. The positions as shown in Figures 123, 124 are described in detail, but it must be understood that, when wrapping, these positions blend into each other so rapidly that an expert packer appears to be picking up apples with his right hand and paper with his left, and placing the wrapped apple in the box. It is readily seen that if the wrap is picked up with the right hand and the apple with the left hand the motions would be reversed. Most apple packers use the general method described, although there are some variations in the details. Beginners should be warned against forming habits in the operations which result in lost motion, for such habits are difficult to overcome. Experienced packers will pack apples about as fast as they can pick them out of the bins. The average packer will pack from 100 to 125 boxes of machine-sized fruit in a day, but packers have been known to pack 325 boxes in ten hours."

When the above operation is completed the loose ends of the paper should be folded neatly under the apple as it lies in the box.

There are several methods of arranging apples in the box, depending upon the shape and size of the fruit. For example, one type of pack is designated

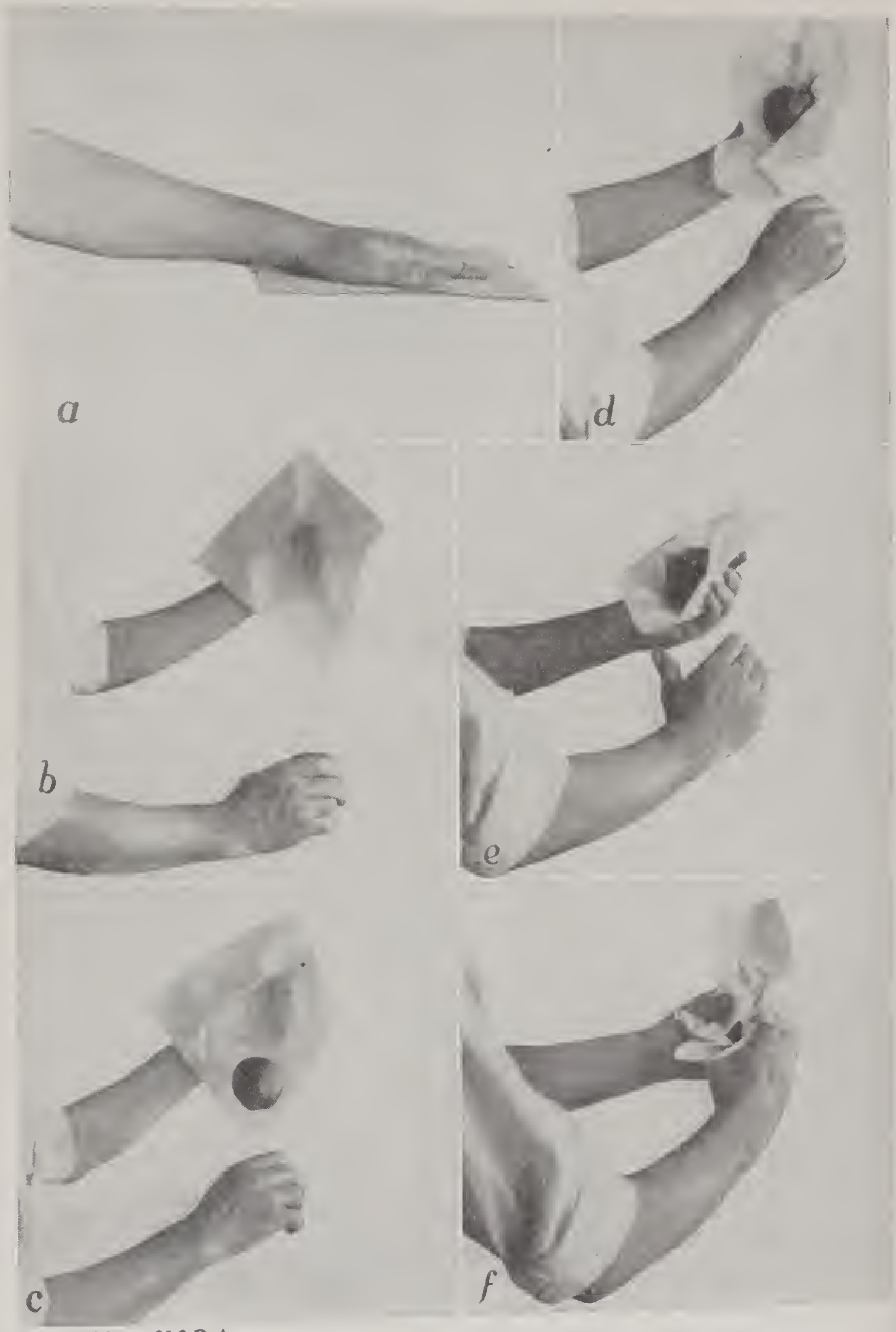


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Figure 123. Method for wrapping apples for box packing is shown here and in Figure 124. (*a*) Pick up the wrap; (*b*) cup the wrap and pick up apple; (*c*) throw the apple into the wrap; (*d*) position of apple upon striking wrap; (*e*) close left hand about apple, note position of right hand; and (*f*) wrapping process, second stage.

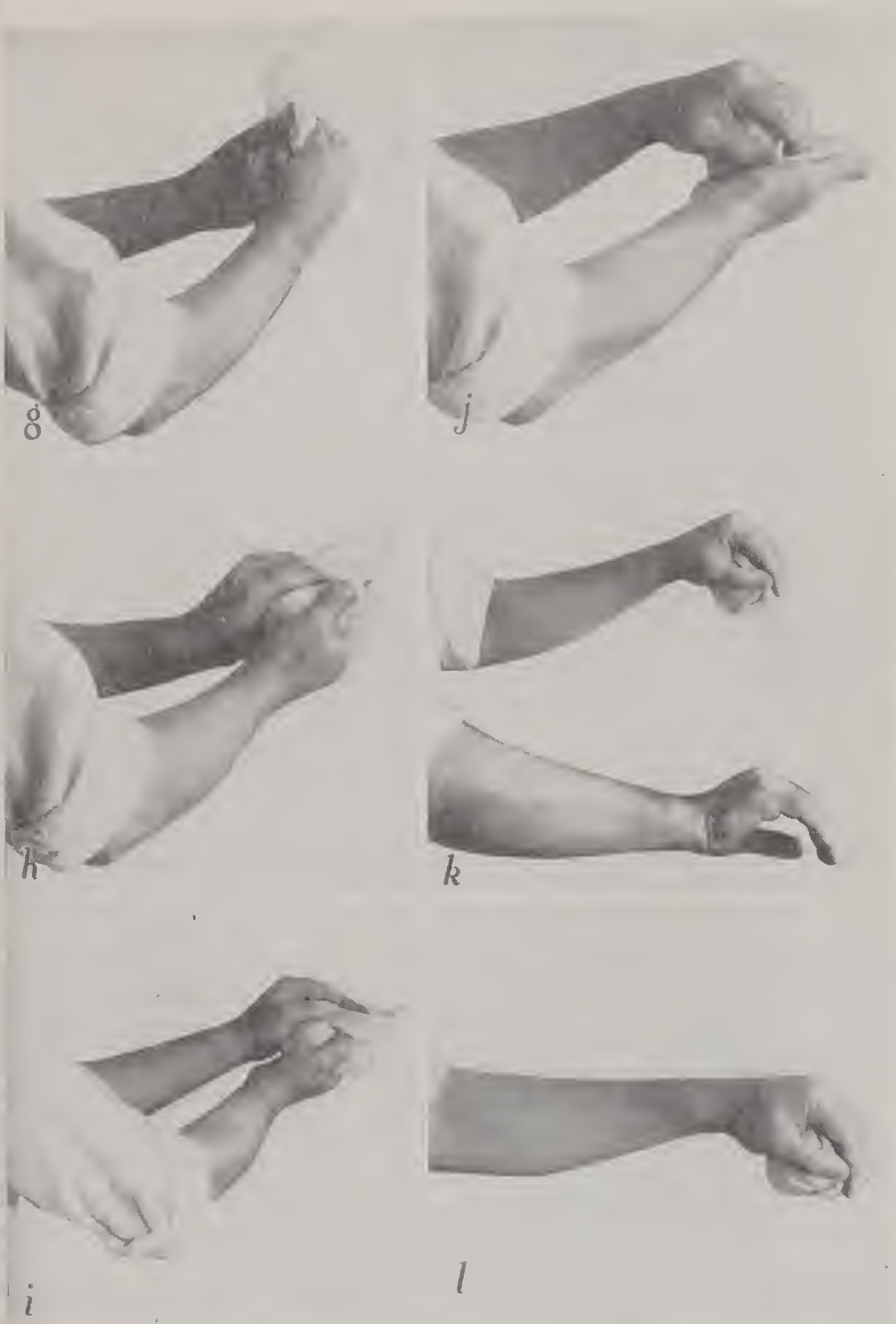

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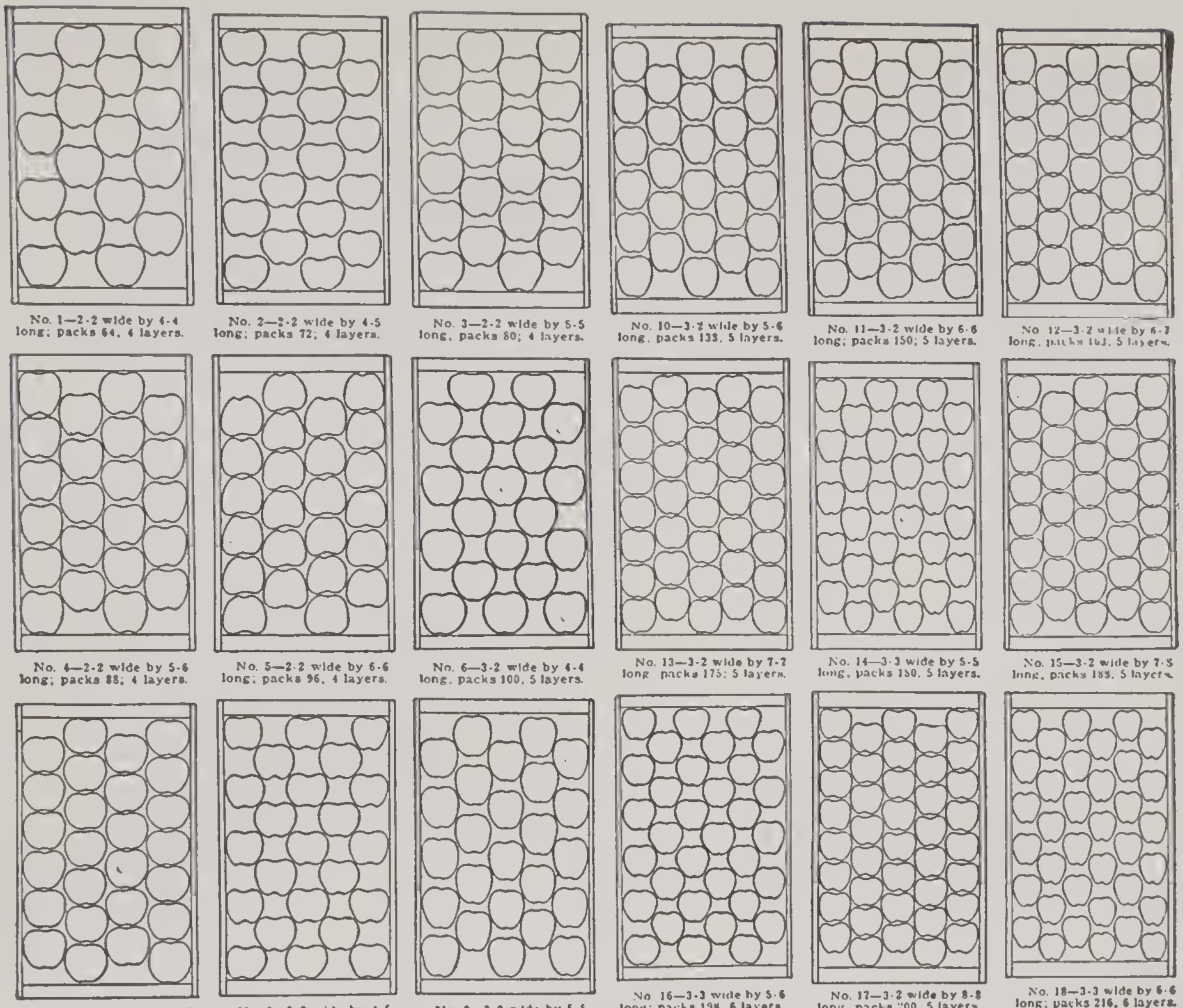
Figure 124. Wrapping process continued. (*g*) Apple held tightly in right hand, pressing apple against cup formed by left hand; (*h*) apple turned within cup formed by left hand, both wrists turning toward right; (*i*) hands turn over completely; (*j*) back of left hand upward, back of right hand downward; (*k*) apple ready for placing in box, right hand reaching for next apple; (*l*) place wrapped apple in box.



No. 1—2-2 wide by 4-4 long; packs 64, 4 layers.

No. 2—2-2 wide by 4-5 long; packs 72; 4 layers.

No. 3—2-2 wide by 5-5 long, packs 80; 4 layers.

No. 10—3-2 wide by 5-6 long, packs 138, 5 layers.

No. 11—3-2 wide by 6-6 long; packs 150; 5 layers.

No 12—3-2 wide by 6-7 long, packs 163, 5 layers.

No. 4—2-2 wide by 5-6 long; packs 88; 4 layers.

No. 5—2-2 wide by 6-6 long; packs 96, 4 layers.

No. 6—3-2 wide by 4-4 long, packs 100, 5 layers.

No. 13—3-2 wide by 7-7 long packs 175; 5 layers.

No. 14—3-3 wide by 5-5 long, packs 150, 5 layers.

No. 15—3-2 wide by 7-8 long, packs 188, 5 layers.

No. 7—2-2 wide by 6-7 long; packs 104, 4 layers.

No. 8—3-2 wide by 4-5 long, packs 113; 5 layers.

No. 9—3-2 wide by 5-5 long; packs 125; 5 layers

No 16—3-3 wide by 5-6 long; packs 198, 6 layers.

No. 17—3-2 wide by 8-8 long, packs 200, 5 layers

No. 18—3-3 wide by 6-6 long; packs 216, 6 layers.

Cutler Mfg. Co., Portland, Oreg.

Figure 125. Because apple varieties vary in size and shape, it is necessary to follow different patterns of packing. Above diagrams illustrate the arrangement and method of packing from 64 to 216 apples per box. The "counts" (or sizes) most frequently seen on the market are 88, 96, 104, 113, 125, 138, 150, and 163 apples per box.

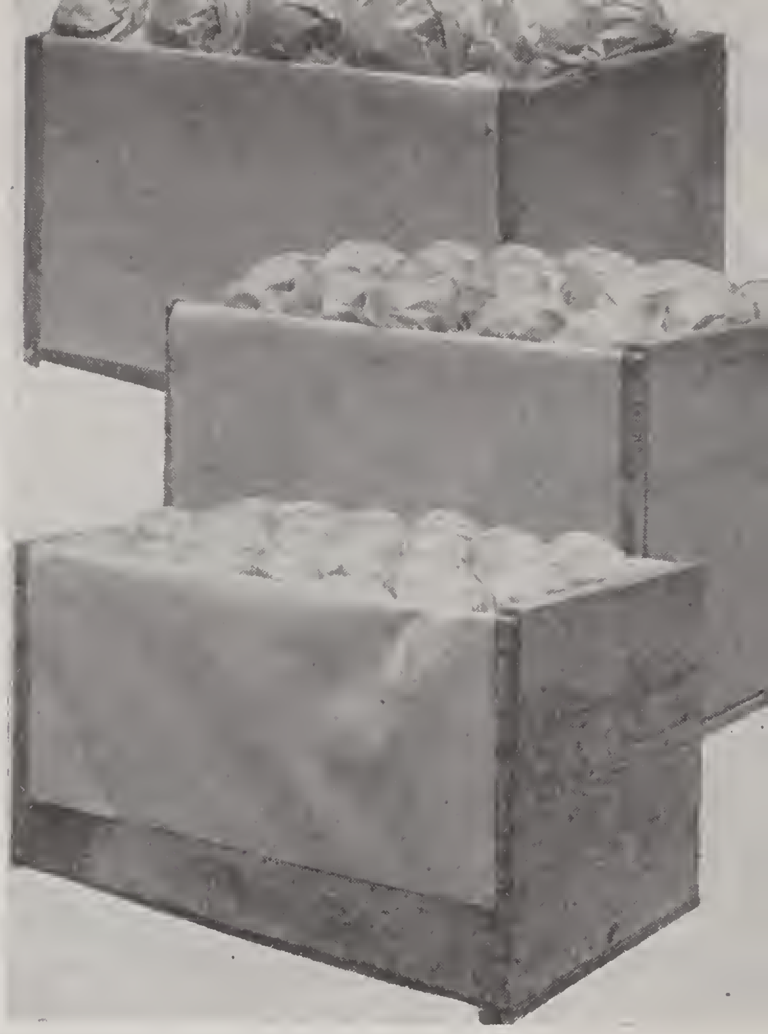
as 2-2 which indicates that each row contains two apples arranged as shown in Figure 125. The 2-2 or 3-2 diagonal packs will accommodate most commercial sizes of fruit. The word "diagonal" means that the apples form diagonal rows so that apples in the second and upper layers lay in pockets formed by the layer below. This equally distributes the weight of each apple on the four surrounding apples below. It may be necessary to pack the largest apples by the 2-1 system and the small apples by the 3-3 system. More specific information is given in Figure 125 regarding the arrangement of apples, depending upon the various sizes and shapes, the number of respective layers, and the final number of fruit per box. These charts are valuable in choosing a packing system on the basis of whether an apple is flat, round, or conical; large or small.

The pack is started nearest the packer at the lower end of the tilted box. There should be no free movement among apples, especially in the first layer. Make a solid fit. This can be done by the packer pulling the layer toward him from time to time and using somewhat smaller or larger sized apples at the end of each layer to make it firm. However, where somewhat larger apples are used on one layer, slightly smaller apples should be used on the next in the same area in order to prevent the bulge from being too much at the top when the box is finished. Each layer must be completed before starting the next.

The experienced packer will regulate the layers and sizes of apples so that in the finished box, apples on either end will rest about one-half-inch above the sides, and one inch above the sides in the center. The bulge should be gradual and uniform with no sags, as shown in Figure 126. The packer can obtain this more or less convex situation by using somewhat smaller apples in the ends and slightly larger apples in the center as the layers are built up.

When the box is finished, it is placed upon the conveyor to the side of the packer, thence it goes to the lidding press shown in Figure 127. After the lid is in place, the box is placed on another conveyor to be labeled with the variety, grade, number of apples in the box, and the minimum net weight. Special automatic inking machines are available. Brand labels are placed on the ends of the boxes either before or after packing. The box is then carefully checked by a checker and sent immediately to storage or to a truck or refrigerator car. Export boxes are wired at either end to further insure against rough handling and breakage overseas.

Packing in consumer containers. For local trade, small corrugated boxes of different sizes and shapes



R. R. Pailthorp, U.S.D.A.

Figure 126. Upper box is packed too high, lower box too low. *Center box shows correct height and bulge.* Upper box will be bruised badly when cover is nailed; apples in lower box may become loose in shipment and bump against each other.

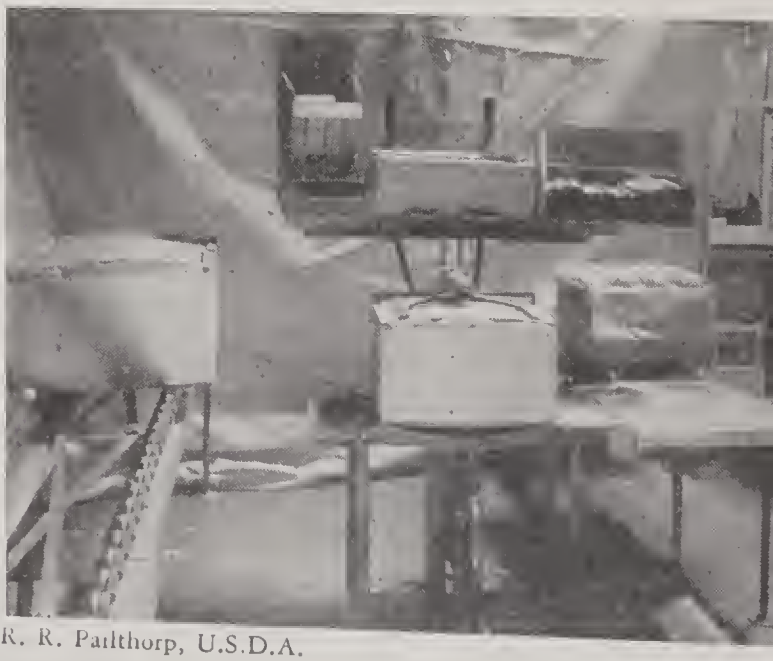


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Figure 127. A convenient system for nailing covers on filled boxes. Boxes come to press on right-hand conveyors, leave on conveyor at left. Press is operated by foot and lid supplies are on upper shelf.

with or without handles are popular consumer packages with housewives at the large chain stores. A small package of apples fits easily in the refrigerator and usually lasts until her next trip to the store. Corrugated and cardboard containers are manufactured to accommodate a definite number and size of apples, which are packed uniformly (Figure 121). Apples are usually packed without wrapping since they will be sold in a short time; some packers may mix colored oiled paper with the fruit, mostly for effect. In the East, these small packages are packed and sold as needed throughout the winter from grower-owned refrigerated storages.

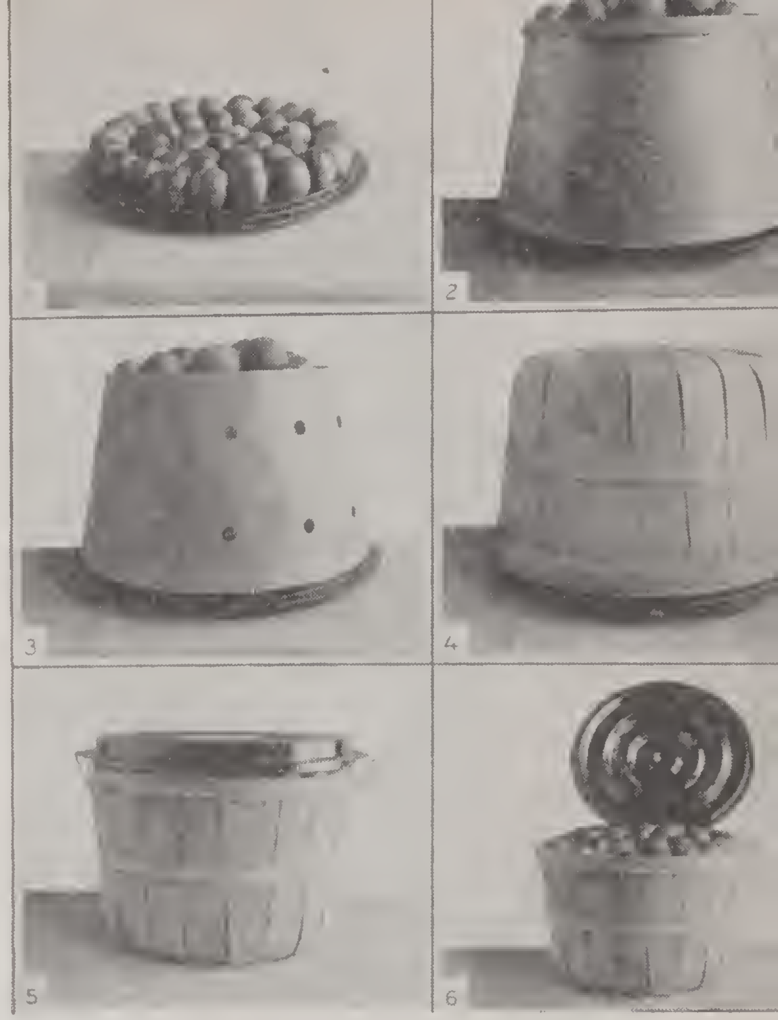
Larger corrugated boxes containing about a bushel of fruit are usually jumble packed for near-by market outlets, although some growers have used the uniform pack system. Purple or pink oiled paper is mixed with varieties susceptible to scald; also, the paper enhances the attractiveness of these packs. If an orchardist is supplying apples to a near-by dealer regularly, these containers may be used over and over in case the store is making several sales by paper sack out of each box.

Packing in baskets. The procedure generally used for packing a basket is shown in Figure 128. The top or face is prepared first on a metal plate or facer which may have circular grooves according to the size of the apples to be packed. The apples are arranged with the stems all in the same direction. The red cheek is placed down; the size of individual apples is adjusted in the face so that each row makes a firm fit. A perforated cardboard liner the same circumference and diameter as the top of the bushel basket is placed over the facing form and gently filled to slightly above the top with an occasional racking. The metal form is removed and replaced by the inverted basket. The basket is then flipped either by hand or by machine and the metal facing cap removed. The face should have a slight bulge and should be uniform over the top with no sagging areas. This slight bulge tends to hold the fruit firmly in place when the top is attached and it gives the face an attractive appearance when it reaches the market. Each basket must contain the grower's name or brand name and address, the variety, grade, and maximum-minimum size of the apples.

Review Questions

1. What is the general procedure and the necessary precautions in estimating the yield of an orchard?
2. What difficulties may be encountered by harvesting apples prematurely or when overripe?
3. List and discuss briefly 3 of the apparently better methods for determining when apples should be picked.
4. List 2 hormone harvest sprays for preventing fruit drop. When and at what concentration are they applied?
5. Describe how a mature apple should be removed from the spur.
6. Why is it important to keep fruit cool after harvesting?

7. What is the present day trend in apple packages as compared with 30 years ago?
8. List the advantages and disadvantages of the Northwestern apple box, Northeastern apple crate, cardboard carton, bushel basket, and the barrel.
9. What is meant by grade of apples?
10. Upon what 2 principles are the methods for sizing apples based?
11. How does a co-operative packing house operate?
12. Briefly discuss the important factors to consider in planning a packing house for convenience and economical operation.
13. What is meant by 2-2, 3-2, and 2-1 pack in preparing boxed apples?
14. In packing a box, how far above the sides should the last layer of apples extend?
15. Briefly give the steps commonly employed for packing a basket of apples.
16. According to the present Federal rulings, what is the maximum amount of arsenic trioxide, fluorine, DDT, and lead, as spray residues, permitted per pound of packed fruit?
17. Give the approximate percentage, time of exposure, and temperature of the acid-washing solution used in apple washers.
18. What are the three types of washing machines used and which is the most effective?
19. Discuss the possibilities and benefits of waxing apples.



R. R. Pailthorp, U.S.D.A.

Figure 128. Method for packing a bushel basket is shown in six steps. (*1*) Face of the pack is laid on metal facing form; (2) metal packing shell with heavy perforated paper liner inside is placed on facing form and filled with fruit; (3) packing shell is removed as pack is held in shape by paper liner; (4) basket is placed over the pack; (5) basket and facing forms are held firmly together while pack is turned upright; (6) metal facing form is removed, and packed basket is ready to have cover attached. Note uniform top of pack with no sags in fruit. The rigid tub-type basket is preferred to this continuous stave-type basket.

Suggested Collateral Readings

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CHAPTER XI

Storing Apples

Over a period of 21 years, Arnold reported that the price of apples on the New York market averaged 22 cents higher in December and 56 cents higher in April than the October price (Figure 129). These normal seasonal price increases make it desirable for the apple grower to devise a means of delaying his marketing to obtain the higher prices. In order to make the venture profitable, however, the cost of storage and any loss from decay of fruit during storage must be less than the increase in price return at the time of marketing. The fact that the venture has been profitable is indicated by the distinct trend in recent years toward grower-owned farm refrigerated storages.

Arnold reports[1] that apple growers owning refrigerated storages in New York received an average of 16 cents more per bushel than fruit growers hiring commercial storage space. Also, the growers with refrigerated storages averaged 34 cents more per bushel for apples than growers who did not store. From 300 growers questioned, Arnold found that the three most frequent reasons given by operators for owning their own storages were (1) cost of storage on the farm is less than that of commercial storage, (2) the grower is better able to choose his market, and (3) the necessity of grading and packing at picking time is eliminated.

In the over-all picture, storages have three chief advantages whether owned by a commercial concern or by the grower himself: (1) to provide a means of holding apples in good condition for several months, thus permitting orderly distribution of the crop and preventing gluts on the market, (2) the orderly distribution of fruit tends to stabilize prices, and (3) a continuous supply of high-quality apples is available to the consuming public almost

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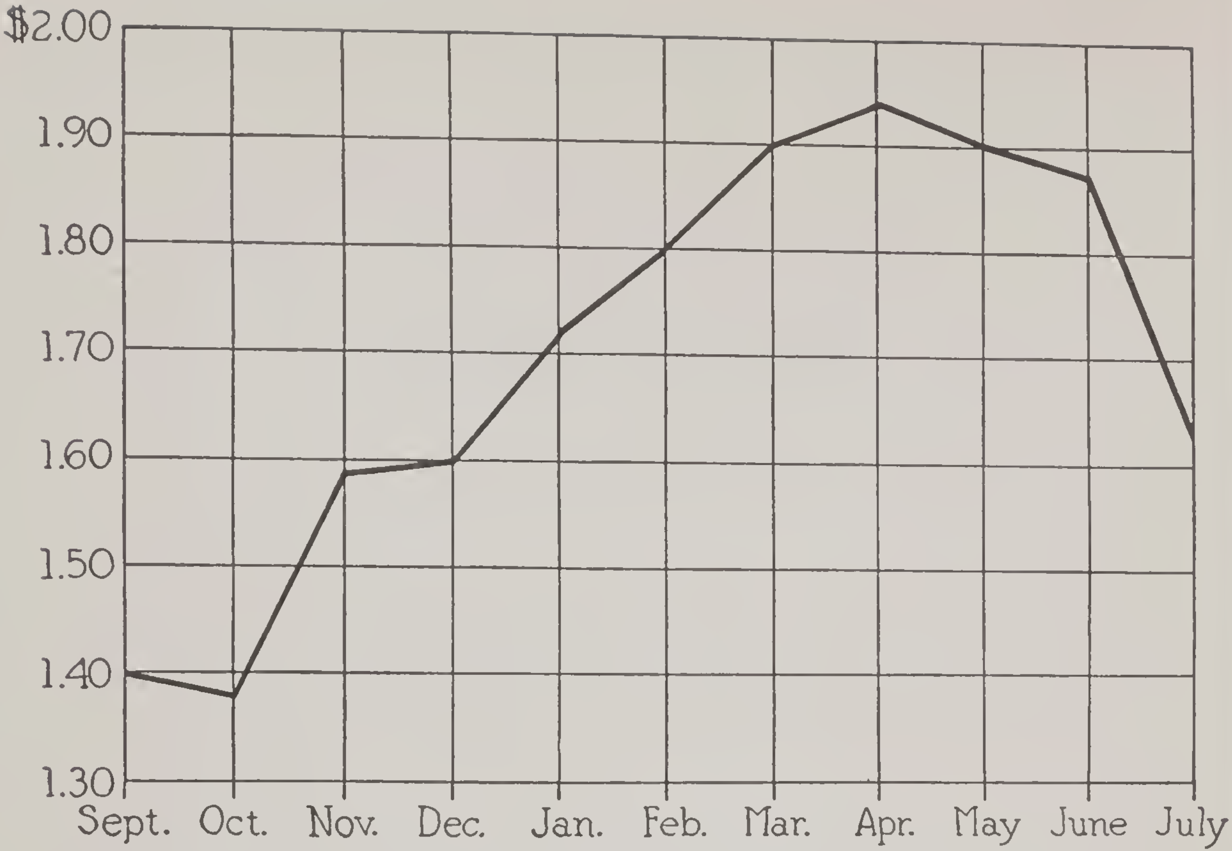
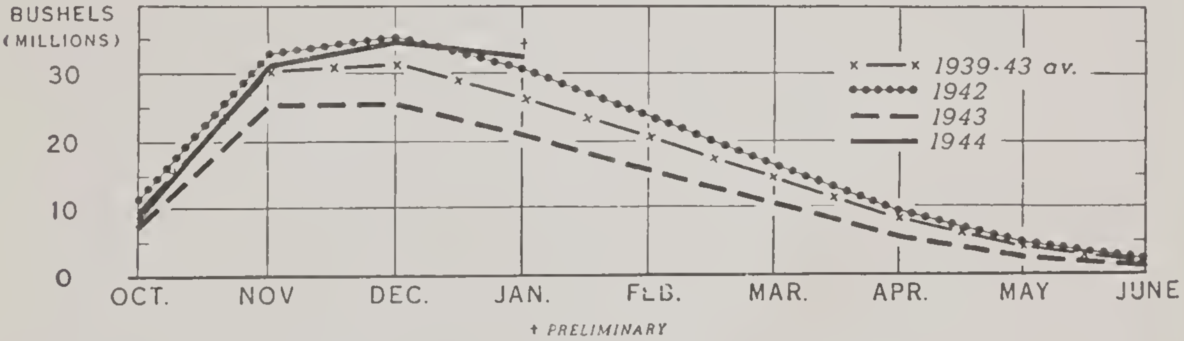
[1] Taken from a mimeographed circular by G. P. Scoville. "Apple yields, prices, markets in Ulster County, Hudson Valley, New York", Cornell University Press. Ithaca. 1933–35.



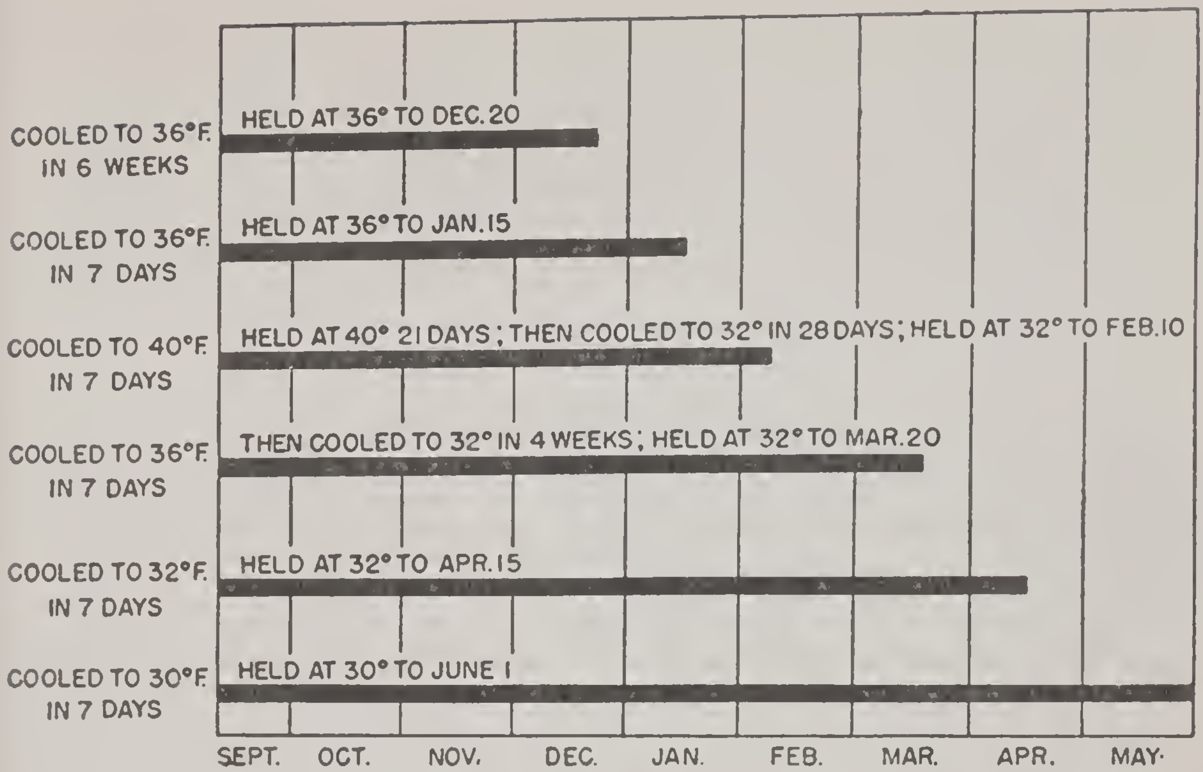
Earl L. Arnold, Cornell University

Figure 129. Average wholesale price of apples per bushel in New York City by months, 1917 to 1937. Prices in November and December are about the same, probably because of apples being forced out of air-cooled storages in sufficient quantity to offset holiday demand. Price drop in June and July is due largely to availability of other early-season fresh fruits.



U.S.D.A. Bureau of Agricultural Economics

Figure 130. Bushels of apples in cold storage on the first of each month from October to June, inclusive. Largest holdings are in November, December, and January.



W. V. Hukill and Edwin Smith, U.S.D.A.

Figure 131. Normal storage life expectancy of Delicious apples when cooled at different rates and stored at different temperatures. For each week of exposure at 70 degrees F. before storage, deduct nine weeks of storage life at 32 degrees; for each week of delay at 53 degrees, deduct one month of storage life at 32 degrees.

every month of the year. This includes such popular varieties as McIntosh and Delicious which without storage would be available to the public only for a few weeks after harvest.

THE FUNCTION OF STORAGES

Fruits are alive. They continually carry on respiration which consists of the intake of oxygen and the evolution of carbon dioxide through the skin. The faster a fruit respires, the faster it ripens. The life processes occurring in harvested fruit are essentially destructive and the basic object in storage is to keep these destructive processes at a minimum by lowering the temperature. For each approximately ten degree lowering of the temperature from 65° to 30° F., the storage life of the fruit is about doubled. For example, if a certain variety will reach prime eating condition at 65° F. in one month from time of picking, the storage season at 50° F. should be lengthened to about two months; at 40° F., it would be extended to about four months; and at 32° F., to eight months. By reducing the temperature two more degrees from 32° to 30° F., the storage season could be prolonged for several weeks beyond eight months (Figure 131).

It is necessary for respiration and other ripening processes to take place in order for the fruit to reach proper eating condition. In ripening, the abundant starch in mature firm fruit gradually changes to sugar; the acids and tannins decrease; pectins change form; and the esters which are responsible for flavor and aroma of a variety, become more pronounced. As these chemical changes proceed, the fruit tends to soften and the ground color changes from leafy green to yellowish shades. Eventually, the aroma and flavor develop fully, an optimum relationship is obtained between the amounts of sugar and acid, and the fruit softens to an ideal "eating stage." At this point, the fruit is said to be fully ripened with maximum quality.

IMPORTANT STORAGE FACTORS

There are two important factors which must be controlled in mechanically refrigerated storages if the fruit is kept in good condition for several months. These are *temperature* and *humidity*. A third factor of *ventilation* is important in the operation of air-cooled storages.

Temperature. Ripening processes of fruit proceed slowly if the temperature is maintained at around 32° F., which is considered most satisfactory for apple storage, except for some varieties, such as Jonathan and Yellow Newtown which may develop soft scald or internal browning unless held at about 36° F. Grimes Golden apples that are intended for early marketing should be held at 35° to 38° instead of at 32°, in order to obtain better quality and avoid soggy breakdown.[1] These varieties preferably should be kept in a separate room if available. The average freezing temperature for fall and winter apples is about 28.5° F. with a possible maximum temperature of 29.5° F.

Humidity. Unless humidity is regulated in a storage, fruit will lose moisture and shrivel. The minimum relative humidity should be not lower than 85 per cent. Relative humidities of 90 to 95 per cent can be maintained without excessive fungus growth if the temperature is held at 32° F. The grower can determine relative humidity by using a sling psychrometer or a wet and dry bulb thermometer with accompanying conversion tables; these are available and inexpensive.

If the inside building surfaces or refrigeration equipment are substantially colder than the humid air of the storage room, condensation of moisture on the walls and coils is likely to take place. This situation is common during the loading-in season when there is a 10° F. or more "split" between temperature of the storage air and the refrigeration coils. Excessive condensation in a storage is undesirable because most of the moisture in the air during the storage holding months comes from the fruit; eventually, this situation will cause shriveling. Condensation of water on the walls and ceiling can be prevented during winter by adequate insulation in the walls to prevent the inner wall surface from becoming substantially colder than the air in the storage room.

Ventilation. Ventilation refers to the introduction of outdoor air into the storage room. Ventilation is necessary for air-cooled storages as a means of lowering temperature, as discussed later. However, ventilation for the benefit of the stored product itself is not essential. This is because in mechanically refrigerated storages of usual construction, carbon dioxide from respiration of the fruit does not build up to the point where it is toxic to the stored product, nor is oxygen reduced to the point where it is limiting in the respiratory process. However, oxygen may become so low in cold storages that some ventilation will be necessary for the comfort of men working in them. Air circulation within a storage, as differentiated from ventilation, is important in moving air away from fruit and preventing the adjacent accumulation of ethylene gas and esters which, respectively, speed ripening and cause storage scald on susceptible varieties. Do not store apples with potatoes, onions, or cabbage.

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[1] For relative lengths of storage season and susceptibility to storage scald for popular apple varieties, see Table 7 in Chapter III.

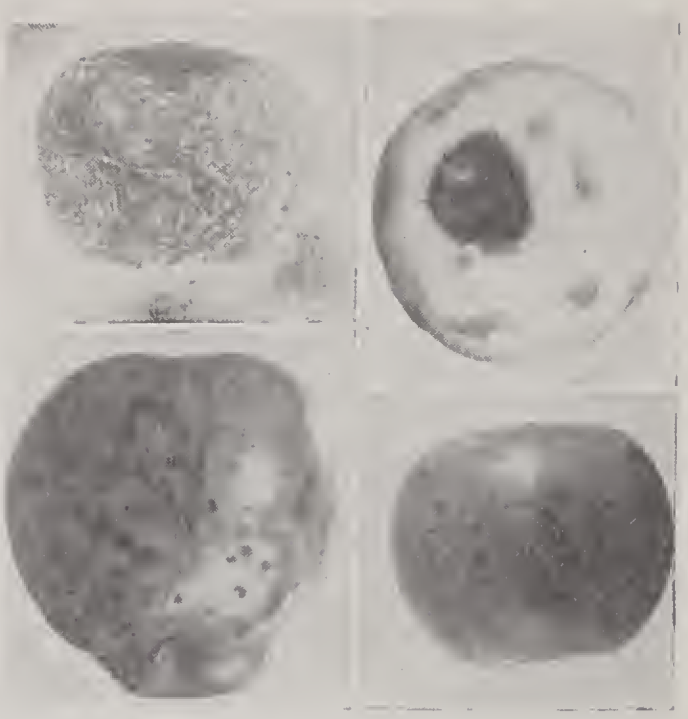

D. F. Fisher, U.S.D.A.

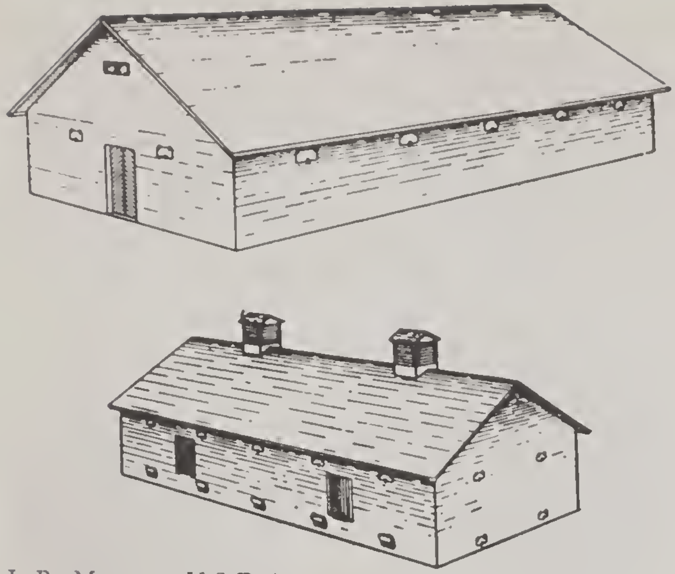
Figure 132. Blemishes and diseases appearing on apples during storage. (Top left) Blue-mold rot, soft and watery, has a musty odor and frequently is covered with bluish masses of spores. Disinfecting and cleanliness in storage room controls disease. (Top right) A partly peeled apple showing how prominent so-called "slight bruises" appear, which emphasizes importance of careful handling at all times. (Bottom left) Bitter pit, a physiological disease, occurs as brownish spongy or corky spots or pits in the flesh just under the skin and usually is the most prevalent on blossom end of apple. (Bottom right) Jonathan spot is a superficial skin disease giving the apple a freckled appearance. Spots are bitter tasting.

TYPES OF STORAGE BUILDINGS

There are several types of storage buildings now in use: (1) the air-cooled storage, (2) air-cooled storage refrigerated with ice, (3) storage refrigerated with mechanical equipment, and (4) the controlled-atmosphere storage.

The air-cooled storage. This is the predominating type of storage in the northern states today, but many of them are being rapidly converted to refrigerated storages. Temperature in the storage room is reduced by opening air intakes and vents and admitting cool air when the air temperature outside is colder than the storage room temperature (Figure 133). The vents and intakes are then closed before the outside temperature rises above the storage-room temperature. Operating costs of these storages are very low. When air-cooled storages are constructed, it is wise to insulate them sufficiently so that later when additional finances are available, they can be converted to mechanical refrigeration.

Air-cooled storages refrigerated with ice. Some storages are built with bunkers which are filled with ice and salt and equipped with fans for quick-



J. R. Magness, U.S.D.A.

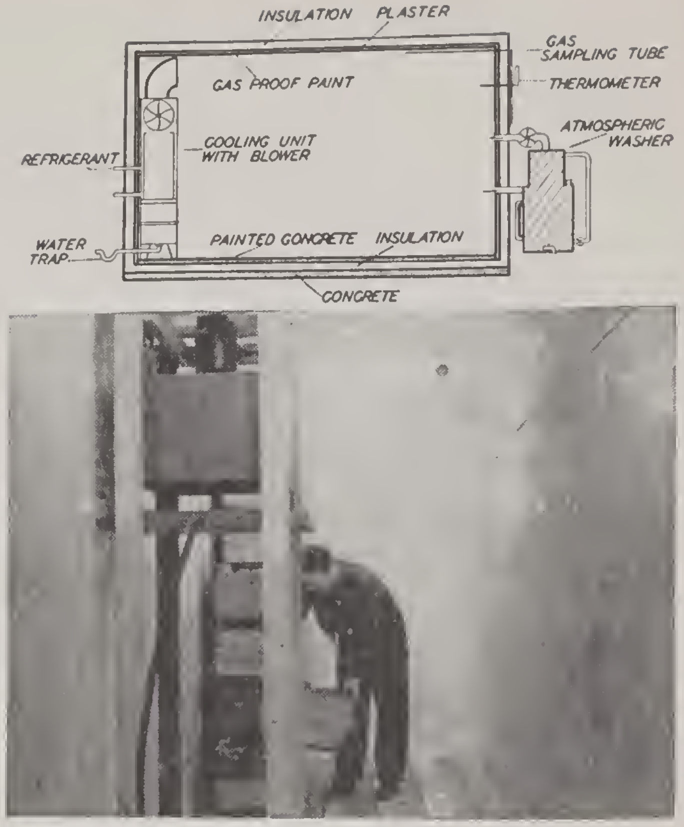
Figure 133. (Top) "Magness" ventilating system for air-cooled storages with air ducts at the top of the walls is more effective in cooling fruit than with the ducts at base of walls. (Bottom) Better cooling of fruit is obtained in air-cooled storages by openings at both the base and top of the walls and with warm-air outlet flues through the roof.

cooling of the fruit during the warmer autumn days. This system may induce high humidities and fungus growth. However, with the use of salt and fans, the rapid melting of the ice will cause some of the atmospheric humidity to condense on the ice, alleviating the high humidity. Some ice water is allowed to accumulate on the floor for more even control of humidity, but the majority is diverted to drains. When the days and nights become cooler in November, or earlier, the storage can then be operated as an air-cooled storage, as described above.

In Michigan, retired refrigerator cars are sometimes used by farmers raising a limited quantity of fruits, flowers, or vegetables. They can be operated as ice-refrigerated storages, or as mechanically refrigerated storages. Net prewar cost of these cars in Michigan was $158.85. Two high-grade fans were installed at $83.50. The cost of icing per bushel was 13 cents; the cost of mechanical refrigeration was 13½ cents. Initial cost of the refrigeration equipment for one car was $1,155.00. With ice bunkers, 300 cu.ft. less room was available in the car (2,178 cu.ft.), than with mechanical refrigeration (2,630 cu.ft.).

Mechanically refrigerated storages. If the grower can afford the initial expense, he should seriously consider the installation of a mechanically refrigerated storage. When properly designed and operated, it has the advantages of (1) prompt cooling of products, (2) maintenance of optimum relative humidity, (3) and an even holding temperature with only a 1- to 2-degree fluctuation. Since this type of storage is becoming the most popular, it will be discussed in greater detail later.

Contolled-atmosphere storage. Interest in this type of storage was stimulated in the United States by work at Cornell University (Figure 134). Controlled-atmosphere storages are used largely in New York and the New England states. The advantages are (1) fruit such as McIntosh can be kept for several weeks or even months beyond its normal storage life, (2) at the higher storage temperature, it is possible to avoid such storage disorders as soft scald, brown core, and internal browning, (3) when the fruit is removed from storage it keeps longer at room temperature than fruit held an equal time by cold storage, (4) a relative humidity can be maintained above 90 per cent with little difficulty from mold growth, (5) it is rodent proof, and (6) operation costs of refrigeration equipment are reduced. Its essential features are as follows: (1) The temperature is maintained at about 40° F. with mechanical refrigeration; (2) The storage room is made gas tight by lining it with sheet metal, overlapping and caulking the joints, and then plastering and using a special paint; (3) The respiring apples reduce the oxygen content to between 10 and 12 per cent, and build up the carbon dioxide to between 5 and 10 per cent (amount of gases is varied with the variety); (4) Storage air circulated by fans through an outside atmospheric washer which removes excessive carbon dioxide given off by the fruit (washer and fans are operated only for short periods once a day, or, as needed); and (5) The storage room is filled, sealed, and not opened until the fruit is sold. This may necessitate several rooms, each operated according to the requirements of the variety and the marketing date. All controls for the chambers are operated from the outside of the room; fruit is inspected through a window. Small samples of the storage air are withdrawn daily to analyze for carbon dioxide and oxygen; the air-washer is operated in accordance with these tests.



R. M. Smock, Cornell University

Figure 134. (Top) Longitudinal section of a controlled-atmosphere pilot chamber for storing apples over long periods, showing equipment and construction. (Bottom) Interior of an experimentally controlled atmosphere chamber, made gas tight with sheet metal overlapped at the joints, sealed with vaseline, caulked, and painted. Cooling unit is shown in foreground.

For a six-month storage period, the cost per bushel in controlled atmospheres was ten cents above storage cost by ordinary cold storages. This was exclusive of operating labor. At the end of the storage period under controlled-atmospheres, the fruit can be removed and kept for two or three additional months under ordinary cold storage conditions or sold immediately. McIntosh stored in controlled atmospheres and sold in June of 1941 on the New York market brought over double the price paid for McIntosh during the previous November.

SIZE OF STORAGE BUILDINGS

In calculating storage building capacities, about 2.5 to 2.8 cu.ft. of storage space are allowed for each bushel. The 2.8 cu.ft. ratio allows ample space for aisles and for proper stacking to facilitate good air circulation. Height of ceiling is recommended at from 12 to 14 feet above the floor.

If the grower desires to build, as an example, a 10,000 bushel capacity storage, he will need approximately 27,000 cu.ft. of storage space (10,000 × 2.7). If the height of the room is 12 feet, this storage will have a floor space of 2,250 sq.ft. (27,000 ÷ 12). Buildings are usually rectangular in shape, varying from 30 or 40 feet in width for a storage of this size. This building might be 36 by 62, 38 by 59, or 40 by 56 feet inside measurements.

INSULATION

Heat may be transferred from one place to another by (1) conduction, (2) radiation, or (3) convection. Heat is transferred from one end of an iron rod to the other end by *conduction*. Metals are usually good conductors of heat and nonmetals are poor conductors, or, in other words, good insulators. *Radiation* is the transfer of heat from one solid material to another through intervening air, as, for example, from a hot stove. Heat is transferred by means of *convection* from a steam radiator. Air coming into contact with the hot radiator becomes warm and rises, while the cold air flows in behind. The entire room is finally heated by convection until the temperature is more or less even throughout.

Insulating materials are judged on the basis of their resistance to flow of heat. Cork either pressed or granulated is generally considered the standard and best all-round insulating material and all other materials are usually compared with it in heat conductivity. Air is one of the best known insulators when properly utilized. Most insulating materials contain numerous small air spaces and their insulating values vary more or less directly with the quantity of entrapped air.

An ideal insulating substance would possess the following properties: (1) relatively high insulation value, (2) a low capacity for absorbing moisture, (3) vermin or rodent proof, (4) odorless, (5) fire resistant, (6) reasonable in cost, (7) does not deteriorate readily, (8) easily applied by unskilled labor, and (9) light in weight. Insulation materials on the market today may be (1) rigid or board type, (2) semiflexible, (3) soft flexible or blanket-forms, (4) dry fills, (5) wet fill, and (6) miscellaneous. Some of these materials add to the structural strength of the building, others do not. It is important to avoid materials having a distinct odor. Cases are known where a waterproofing material imparted a disagreeable taste to stored products for two years before the odor wasted away.

According to Arnold, corkboard and granulated cork were by far the most popular insulation materials used in New York refrigerated storages. Out of 87 storages checked, 50 storages used corkboard, 23 used granulated cork, seven used sawdust or shavings, two rock wool, two air space, and one insulating board. If the insulating value of medium density corkboard is taken as 100, the relative value of other insulating materials is shown on page 215.

Corkboard (low density)	111
Corkboard (high density)	90
Insulating boards (sugar cane fiber, wood, cornstalk, wheat straw)	88–94
Rock cork	81
Synthetic rubber board	158
Regranulated cork	88–97
Mineral or rock wool	107–115
Redwood bark	107
Expanded mica	100
Dry sawdust	29
Dry shavings	42
Cinders	24
Brick wall	6
Concrete	4
Expanded mica concrete	50
Lumber	29–38
4-inch hollow tile	46
8-inch hollow tile	70
12-inch hollow tile	112
12-inch interlocking tile	150
Soil	6–37

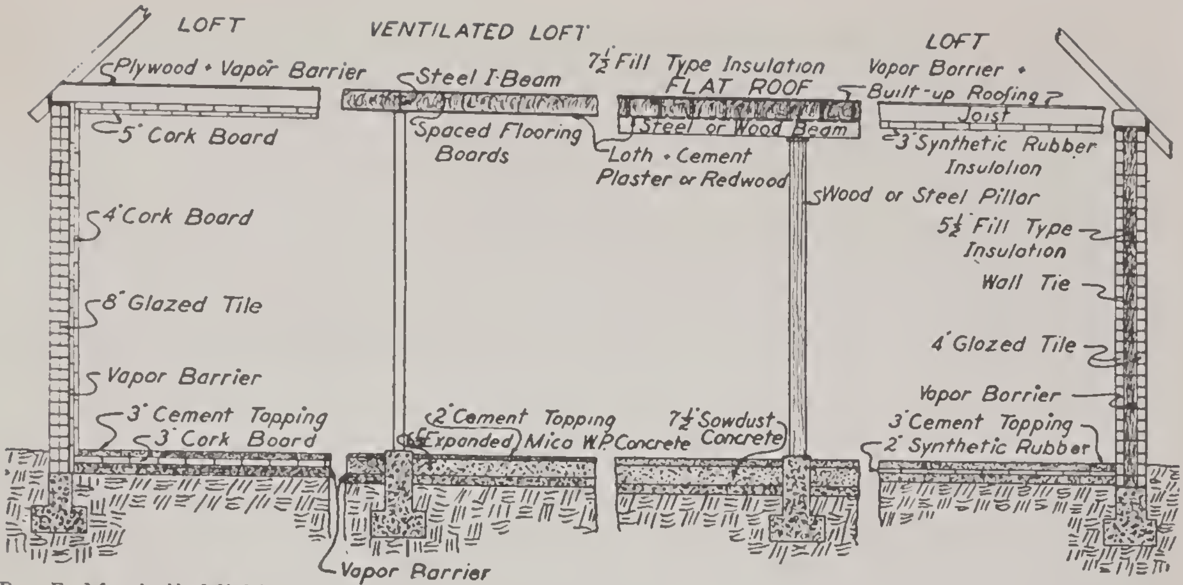
Insulation needed. As stated previously, if an air-cooled storage is constructed, it is well to insulate the walls, floors, and ceiling sufficiently so that the storage later can be converted to a refrigerated storage. An air-cooled storage, as such, requires only two inches of cork or its equivalent in other materials in the walls and ceiling to prevent freezing of the fruit during the coldest winter weather in the commercial apple growing regions. If fill-type insulation material is used, a thickness of about 50 per cent greater than corkboard is advisable.

For refrigerated storages, the side walls should have four inches of corkboard insulation or its equivalent (five to six inches of fill-type materials). Five inches of corkboard or its equivalent (seven or eight inches of fill-type insulation) should be used in the ceiling. The floor requires three inches of corkboard or its equivalent because the ground temperature usually remains at about 55° F., and without insulation it will continually contribute heat to the storage room.

VAPOR BARRIERS

Insulation materials must be kept dry because water is one of the best conductors of heat. Water vapor barriers in the walls, floors, and ceiling are essential. Movement of water vapor in most cases is from the outside to the inside; this is when the outside temperature is higher than the inside temperature. For storages to be operated at 32° F. throughout the year, it is recommended that a vapor barrier be applied between the outside supporting wall and the insulation. For storages operated at 32° F. from peach harvest until spring, no vapor barrier is needed if the outside supporting wall is well laid face tile. Face tile itself is a good vapor barrier.

Since there is no perfect vapor barrier, it is necessary to use a material which reduces the vapor movement as much as possible. Building papers used as a barrier should be asphalt impregnated, coated and glossy surfaced, and should weigh at least 35 pounds a roll of 500 sq.ft. Rough-coated masonry walls should first be painted with two applications of cement plaster to give an even surface for the vapor barrier. Then the interior surfaces of the walls, ceilings, and floors are given a coat of asphalt paint to seal the



Roy E. Marshall, Michigan State College

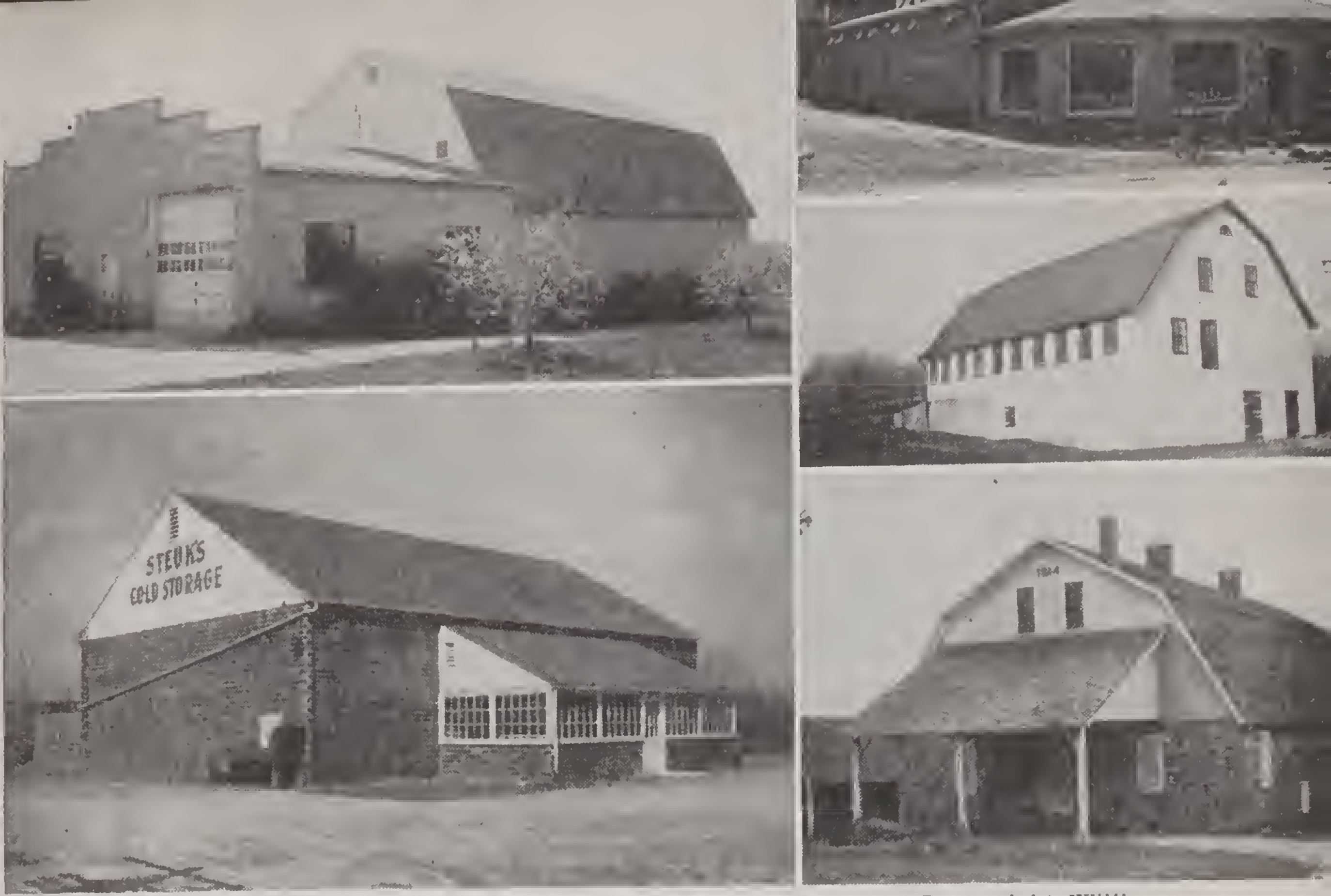
Figure 135. Several methods of construction are shown for refrigerated farm storages. Left section shows typical construction of walls, ceiling, and floor insulated with cork board. Other sections show various materials in sufficient amounts to provide some insulating values as corkboard. Ceiling construction should provide unobstructed air flow in storage room. The insulation of junctions of walls and floors, and walls and ceilings should be continuous.

surface, after which two layers of asphalt impregnated paper are cemented over the asphalt coated surfaces. No vapor proofing should be placed on the inside of the insulation material. If there is either natural or forced air ventilation in the loft, there is no need for a vapor barrier in the ceiling. Air-cooled storages with face-tile construction do not need a vapor barrier.

STORAGE CONSTRUCTION

Walls. In the smaller refrigerated storages, a common type of construction is a four-inch glazed tile wall and an inner wall of four-inch glazed hard tile set three to six inches inside the first wall, with the space between the two walls containing fill-type insulation material (Figure 135). Regranulated cork, expanded mica, and shredded redwood bark fiber are commonly used filling materials. A vapor seal, if it seems advisable, is applied to the inner surface of the outer wall. A common construction of large commercial storages consists of a masonry wall of concrete, tile, or brick at least eight inches thick, a vapor barrier, and then four inches of corkboard applied in two layers of equal thickness. The corkboard is set in hot pitch or Portland cement. This construction is entirely satisfactory for farm storages but it is usually a little more expensive.

Doors. A *minimum number* of doors should be used. A 4 by 6½-foot door size is most desirable. A considerable saving in refrigeration can be obtained if one or more doors about two feet square are provided, through which fruit can be moved on roller conveyors in and out of the storage (Figure 136). A heavy canvas flap in these doors helps retain the cold air in the storage room. Standard refrigerator doors may be purchased, but it is usually cheaper to have local carpenters make them.

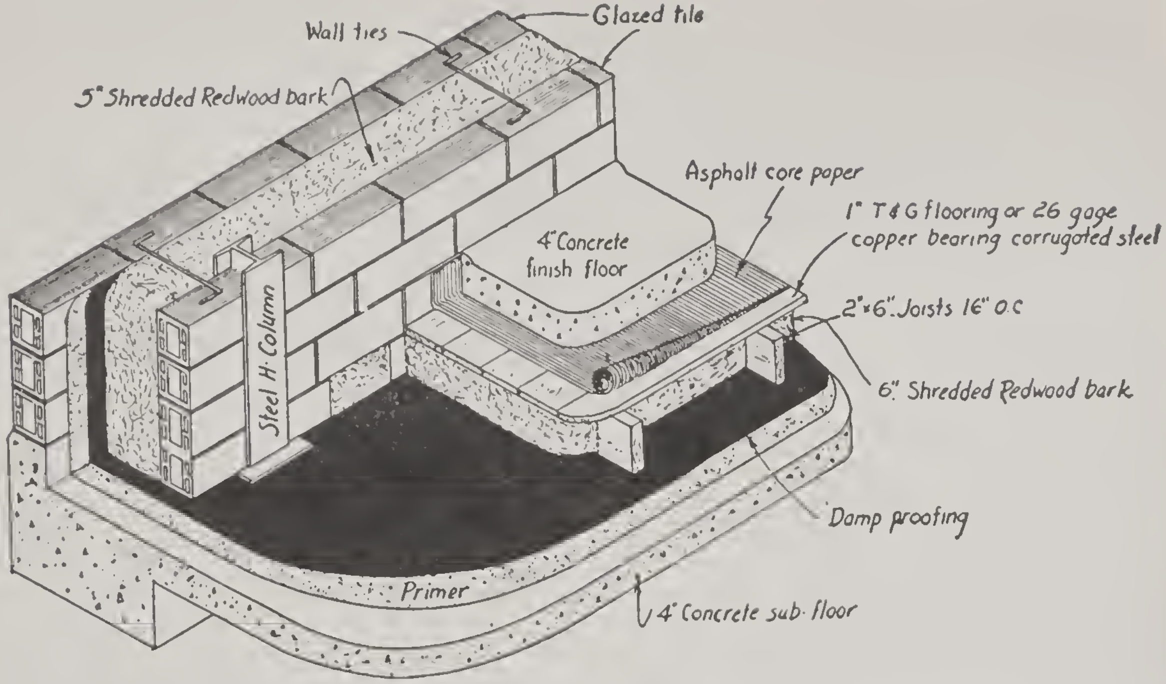


(Top left, Top right, and Bottom right) Roy E. Marshall, Michigan State College. (Bottom left) William Steuk, Venice, Ohio. (Middle right) C. I. Gunness, Massachusetts State College

Figure 136. Farm apple storages. (Top left) Fourteen thousand bushel refrigerated storage insulated with five inches of regranulated cork in the walls and floor and seven inches in the ceiling. Storage was first air-cooled with forced ventilation, then changed to forced-air circulation through melting ice, and finally equipped with mechanical refrigeration. (Bottom left) A ten thousand bushel refrigerated storage with sales room in front. Note small entrance door for fruit at left and water-cooling system for refrigeration condenser at rear. (Top right) Building divided into four sections; 20- by 36-foot room in rear serves for grading and handling operations. Next section is a 40 by 36-foot air-cooled storage for late-maturing apple varieties, while front section is refrigerated. (Middle right) A thirteen thousand bushel frame storage with lower floor and half of upper floor refrigerated; packing room occupies half of upper floor. Box storage is in the attic. Shipping platform will be added to front end. Walls and floor are of concrete, insulated with cork; frame walls and ceiling insulated with regranulated cork. Storages cooled by a single blower on first floor equipped with ducts to each room. (Bottom right) Air-cooled storage in Michigan with nine-foot sorting room across front built in 1914 for two thousand dollars. No freezing of fruit has resulted in thirty seasons of operation.

Ceiling. About 20 to 25 per cent more insulation should be provided in the ceilings than in side walls. Corkboard or other rigid type insulating materials can be applied below the joists as shown in Figure 135. Popular types of ceiling construction in Michigan are either lath (metal preferred) and cement plaster below the joists, copper-bearing sheet metal, or redwood boards. The area between the joists is filled with dry-fill insulation, allowing it to rest on the rigid ceiling construction. If a loft floor is placed above the ceiling, a two-inch air space should be left between the fill-type insulation and the floor in order to provide ventilation and drying to the insulation material. Insulation should be continuous at the joints of the ceiling and walls. There should be no obstructions on the ceiling surface which will interfere with a clean sweep of cold air across the top of the stacked fruit. If beams are necessary, they should run parallel with the air flow.

Floor construction. Floors in air-cooled storages are seldom insulated.



Roy E. Marshall, Michigan State College

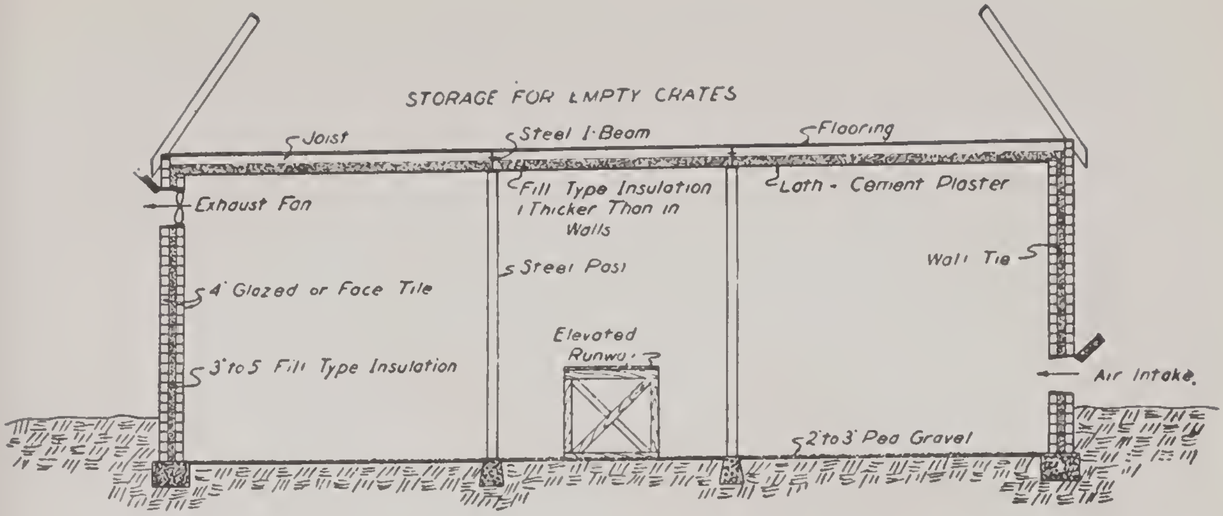
Figure 137. This diagram shows the junction of wall and floor of a refrigerated storage. Instead of lumber and shredded redwood bark between concrete slabs of floor, two to three inches of cork board, rock cork, or similar materials may be used. In place of the steel H-column, masonry pilasters may be built into and outward from the outer wall unit.

The usual procedure is to level the dirt floor, fill in with several inches of clay soil, pack well, and add two inches of pea-gravel (Figure 138). If a concrete floor is used in the air-cooled storage, it should be level in order to permit water to stand.

Refrigerated storages must have insulated floors because uninsulated floors may increase the refrigeration load by 30 per cent. Methods of floor construction for farm storages are shown in Figures 135, 137. A standard construction for commercial storage floors is to pour a concrete base three to four inches thick, apply an asphalt vapor barrier on top of the concrete, apply three inches of corkboard in asphalt, mop the top of the corkboard with asphalt, and then finish with a three-inch cement topping for wearing surface. If other types of construction are preferred, an equivalent insulation should be provided. Floors should be designed to support 210 pounds per square foot for a ten-foot ceiling and 260 pounds per square foot for a twelve-foot ceiling when loading space is figured at 2.5 cu.ft. per bushel.

THE AIR-COOLED STORAGE

This type of storage, as stated previously, is cooled by judiciously admitting air colder than storage-room air and excluding air warmer than that in the storage. The arrangement of air intakes and vents, as shown in Figure 138, is fast (with fans) and efficient in evenly cooling fruit throughout the storage. The cold air enters at several intakes in the lower right wall, and is drawn through the fruit and exhausted by fans in the upper left wall. Well-insulated above ground storages are better than storages built into a bank or sur-



Roy E. Marshall, Michigan State College

Figure 138. Cross-section of an air-cooled storage showing insulated walls and ceiling and a pea-gravel floor. Cold outside air enters ducts at right, passes through stacks of stored fruit, and is exhausted by fans in upper-left ducts.

rounded by soil. The temperature of the earth runs between 50° and 60° F. which is considerably higher than the air temperature on many days during the storage season.

Ventilation may be by gravity or by forced air using power. The fans are located in the upper wall vents or the ceiling flues. With forced air ventilation, inlet openings at the base of the walls should be two and one-half to three feet square with doors hinged at the top; with gravity ventilation, the intake areas should be at least four square feet. These entrances must be covered with hardware cloth to keep out rodents.

Air-cooled storages are often made by converting a barn, school house, or old church, using the necessary wall, floor, and ceiling insulation. If a barn is converted, the height clearance of the storage room should not be less than eight feet which may necessitate the lowering of the floor. Floors must be rat proofed with hardware cloth. With stone or other masonry walls, provision must be made for at least three inches of fill-type insulation inside the old wall. A four-inch tile wall may be erected as an inner support for this insulation, or two- by four-inch studs can be set inside against the walls; paper, laths and plaster are then applied in this order to the studs. Fill-type insulation is placed between the two by four studs. Hardware cloth will be necessary in the walls to eliminate rodents, unless the lath is metal or the inside wall is tile.

The ceiling must be insulated with four inches of fill-type insulation and made rat proof with hardware cloth. Insulation is placed between the joists. The underside of the joists may be covered with either (1) hardware cloth, paper, and tongue- and groove-lumber, (2) metal laths and plaster, or (3) with sheet metal.

Management of the air-cooled storage is as follows: thoroughly wet the floor before and several times during the storage season. Leave the fruit in the field to cool over night and store it early the next morning. Open all cold air intakes (and start fans) when outside temperatures are colder than inside temperatures, especially during the fall and loading season when it is desirable to cool the fruits to a low temperature level as soon as possible. Thermometers must be placed inside and outside of the storages and watched closely. It should not be forgotten that the respiring fruit continually gives off heat. Many nights, as well as days, in the fall are often warmer than the storage temperature. It cannot be overemphasized that the goal for the common storage is to lower the temperature as fast as possible to 32° F. During many of the winter days, it will be necessary to keep the storage closed in order to prevent freezing of the fruit. It is dangerous to cool the storage below 30° F., because fruit begins to freeze at 28° and 29° F. The biggest problem in winter is to maintain the humidity as near 85 per cent as possible. This can be done by wetting the walls, floor, and products frequently or installation of an automatic humidifying system.

Capacity of common storages vary from 2500 bushels to 12,500 bushels or more. Cost of construction is cheaper on a per bushel basis for the larger storages. Prewar costs per bushel of storage capacity in Michigan were from 35 to 40 cents, including, in some cases, dry storage space for baskets, crates, ladders, and other equipment above the storage room and also an adjacent sorting room or sales room. A few storages have cost as much as 50 cents per bushel. Maintenance cost of air-cooled storages is about five cents per bushel capacity per year on the basis of costs of operation, interest on the investment, depreciation, insurance, and repairs. Common storage space is rented at about ten cents per bushel for the season with the owner of the products supplying the labor for moving the fruit in and out of storage.

In regions such as southern Indiana where temperatures are likely to be warm for the first few weeks in autumn, installation of ice bunkers in air-cooled storages is sometimes practiced for lowering the temperature during these warm periods. While the practice is inferior to mechanical refrigeration, it may prolong the sales period of Grimes Golden and Jonathan past the holiday season. Seasonal cost of icing and operating the ice room in Indiana varies between 16 and 26.6 cents per bushel with an average of 20.8 cents over a period of several years. In New York, however, and most northern states, this practice has not been recommended.

REFRIGERATED STORAGES

Estimating refrigeration load. *A word of caution is advisable. Salesmen for refrigeration equipment are helpful in planning a storage and estimating needed equipment. The grower must be careful in quoting the rate of movement of fruit into the storage during the harvesting season. It is a common mistake for growers to underestimate this rate of movement; the grower must base his estimate upon the peak loading day. Salesmen are in competition and in order to underbid their competitors, inadequate refrigera-*

tion equipment is often sold and installed. It is, therefore, most essential that prospective owners of refrigerated storages know, or seek the advice of people who know, if the equipment in question has enough capacity to provide the desired conditions of both temperature and humidity under normal operation conditions for the storage.

Any equipment that will handle the peak cooling load during harvest will be more than adequate for the rest of the storage season. The following quotation by Marshall gives the problems and methods involved for estimating the refrigeration load.

"The amount of refrigeration in British thermal units (B.t.u.) or tons of refrigeration (one ton of refrigeration is equivalent to the heat absorbed in changing one ton of ice at 32° F. to water at 32° F. or 288,000 B.t.u.) required may be calculated rather accurately if the following information is available: (1) the area in square feet of the walls, ceiling, and floor; (2) the thermal transmission factors for the walls, ceiling, and floor or the detailed construction of each; (3) the average maximum difference between the outdoor and the storage room temperatures; (4) the maximum daily rate of loading of the product to be stored; (5) the maximum loading-in temperature of each kind of product and the length of time allowed to cool it to the desired holding temperature; and (6) the amount of heat that will be generated by workmen, motors, and lights in the storage room. In a more general way, one must calculate the amount of heat leakage through the walls, ceiling, and floor during the warmest period that the storage will be in operation, must calculate the cooling load for introduced goods, must calculate the heat generated by respiration of the stored goods, and must calculate or make an allowance for heat generated by workmen, motors and lights. Obviously, the calculation of the amount of refrigeration needed to accomplish a given job is rather complicated. Enough experience has been gained with farm storages so that it is possible to provide some more or less "rule of thumb" information that may serve as a guide in determining if the refrigeration requirements are being approximated.

"The amount of refrigeration required to take care of the daily heat leakage through walls, ceilings, and floors with *standard insulation* during the warmer portions of August and early September in Michigan for storages of 5,000, 10,000, 15,000, and 20,000 bushels capacity would approximate 0.9, 1.3, 1.9 and 2.2 tons, respectively, or from 0.11 to 0.15 ton per 1,000 bushels capacity. If the floor or ceiling insulation amounts to less than what is termed standard (standard recommendations given in this chapter), correspondingly greater refrigeration capacity would be needed to counteract heat leakage, and *if the floor is uninsulated, two to three times as much refrigeration would be needed to take care of heat leakage into the rooms.*

"The amount of refrigeration required to remove the field heat from products varies directly with the temperature range through which the fruit must be cooled and with the kind of product. Time or rate of cooling is immaterial if uniform quantities of product are loaded in daily. The same amount of refrigeration is required to do this cooling in one or two days as would be required to do the work in a week. To reduce the temperature of 1,000 bushels of peaches from 82° to 32° F. requires more than eight tons of refrigeration. The same quantity of apples maturing later when outdoor temperatures are lower, could be cooled from 72° to 32° F. with about six tons of refrigeration. The difference between the peaches and apples may be explained mostly by the ten-degree difference in initial temperatures and partly by the heavier weight of peaches.

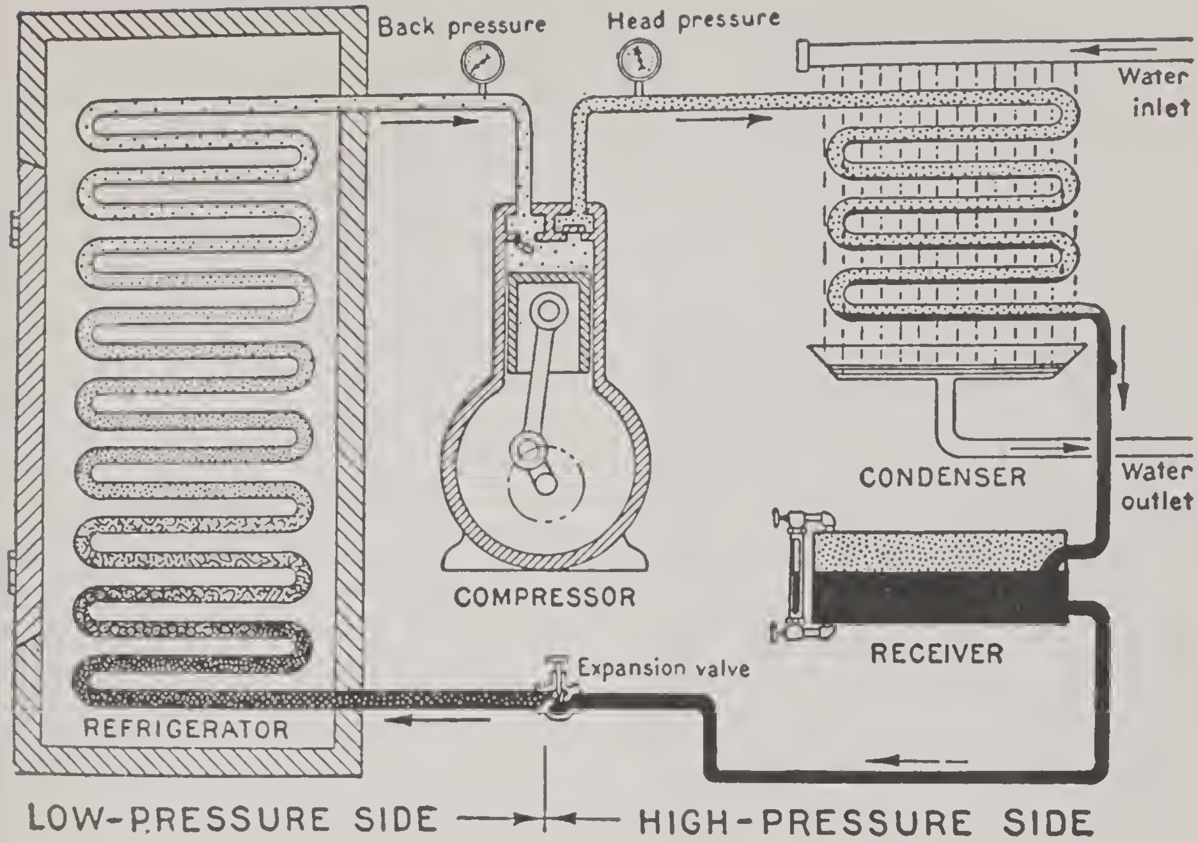
"The heat generated by respiration of fruits must be taken into consideration. Apples at 65° respire about eight times as rapidly as apples held at 32° F. This means that the former generate eight times as much heat as apples at 32° F. Therefore, if fruits are cooled slowly, they generate several times as much heat as do those that are cooled rapidly. The amount of refrigeration necessary to counteract heat generated while apples are cooling through a range of 40° F. in six days is at least one-third as much as the cooling load amounts to. If the cooling time is reduced to three days, only one-half as much refrigeration will be needed to counteract heat of respiration. This means that the 1,000 bushels of apples referred to in the last paragraph would require an additional two tons and one ton of refrigeration, respectively, for cooling during a six-day or a three-day period.

"Nearly one-fourth ton of refrigeration per day is required to neutralize the heat generated per horsepower by electric motors running continuously in the storage room. A workman generates about one-fourth as much heat in an hour as does a one horsepower motor, and nine electric lamps of 100 watts each would be the equivalent of another such motor.

"If the maximum daily rate of loading fall apples into a storage is 10 per cent of its holding capacity (it should not be more than this, preferably), there should be about one ton of refrigeration capacity for each 1,000-bushel capacity of the storage. If the loading rate is 7 per cent of the total capacity of the storage, one should be able to get good refrigeration with a machine that will deliver three-fourths ton for each 1,000-bushel capacity of the storage. These suggestions are approximations that take into consideration all the factors discussed in preceding paragraphs, but they must be regarded as rather rough measuring sticks for storages that are adequately insulated.

"Once the stored goods are cooled to a holding temperature of 32° F., little refrigeration is required to take care of heat leakage and the heat of respiration. One ton of refrigeration per day would probably be ample to maintain the temperature in a 10,000-bushel farm storage in late fall or early winter when outdoor temperatures are relatively low."

Refrigerants. A refrigerant is a liquid that evaporates or boils at low temperatures and relatively low pressures. When the liquid refrigerant boils



W. V. Hukill and Edwin Smith, U.S.D.A.

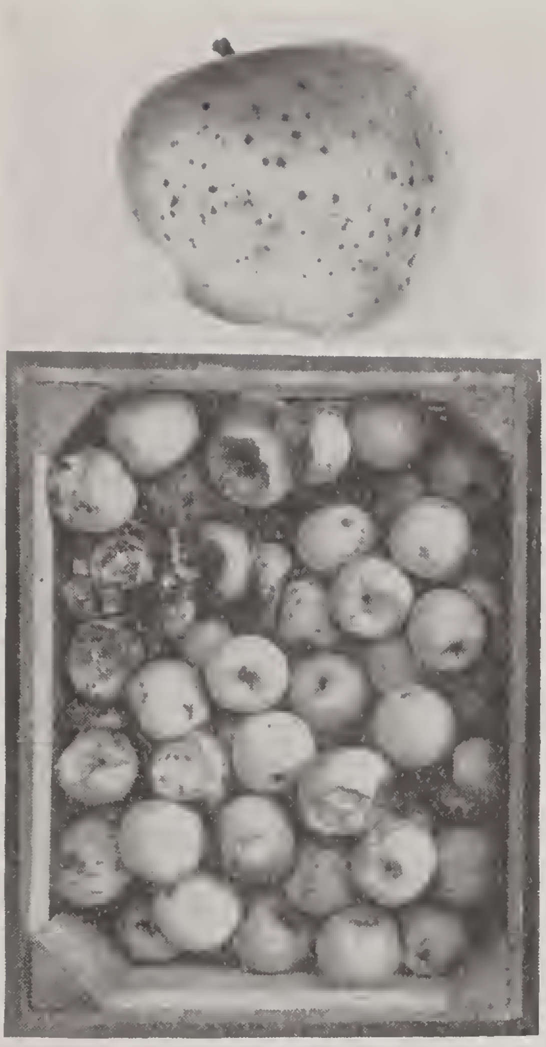
Figure 139. Essential parts of a compression refrigeration system. Refrigerant leaves compressor as a gas (dense stippled area) under pressure; gas is cooled and condensed to a liquid (solid-black area) in the condenser and thence stored in the receiver tank; the expansion valve is automatically opened by thermostat in storage room, admitting liquid refrigerant to expansion coils in storage room; liquid refrigerant gradually changes to a gas and in the process absorbs heat from the storage room; gas then returns to compressor and operation is repeated.

and changes to a gas in the storage-room coils, it absorbs heat from the room and the stored product. The gas with the heat is then piped outside the storage room where it is compressed and passed through a condenser which absorbs and dissipates the heat, changing the gas back to a liquid for repeated use.

Equipment needed for circulating and changing a refrigerant from a gas to a liquid is shown in Figure 139. The *compressor* sucks the refrigerant vapor from the evaporating coils, and compresses it. The vapor under pressure is then forced by the compressor into a set of coils known collectively as the *condenser* where cool air or water extracts the heat from the vapor and reconverts it to a liquid. The liquid is stored in a tank and released to the storage-room coils by an *expansion valve* which is opened and closed by a thermostatic switch. This process is done over and over in cooling and maintaining a cold storage-room temperature.

Refrigerants commonly used are Freon, ammonia, and methyl chloride. Freon is probably the most popular refrigerant in farm storages. It is odorless and nontoxic, but leaks are difficult to locate. Ammonia gas is toxic to fruit if it escapes in large quantities (Figure 140). Methyl chloride has the disadvantage of being poisonous to man in high concentrations. Cost of equipment and the refrigerant in the long run is about the same for the three refrigerants listed.

Compressors. A compressor is essentially a pump. It somewhat resembles a gasoline engine in that there is a crank shaft, connecting rods, pistons, and valves which require care similar to that needed by the parts in a gasoline engine. Compressors are either water-cooled or air-cooled. Those using Freon or methyl bromide are smaller, lighter, and are operated at faster speeds with less vibration as compared with the ammonia compressors. In buying compressors, company reputation is more important than mechanical characteristics, since reliable companies will guarantee and repair their equipment.



Donald Comin, Ohio Agr. Exp. Sta.

Figure 140. (Top) Ammonia injury to apple resulting from ammonia-gas leakage from coils in storage room. (Bottom) Rats can cause considerable damage to stored apples; damage can be prevented by lining storage with sheet metal or one-fourth-inch mesh galvanized-wire cloth.

The capacity of a compressor depends upon the number of cylinders, their diameter, the length of stroke, and the speed at which the compressor operates. Capacity is usually measured in tons of refrigeration per 24 hours, but this varies with temperature of refrigerant, cooling medium surrounding the condensing coils, and the speed of rotation. For example, a compressor using Freon will deliver 9.75 tons of refrigeration at a refrigerant gas temperature of 10° F., and 20.8 tons at a gas temperature of 30° F. At twice the operating speed, the machine will produce about twice as much refrigeration. The h.p. of a motor required to operate a compressor runs about 1.5 h.p. per ton of refrigeration for farm-size installations of from 2 to 20 tons capacity.

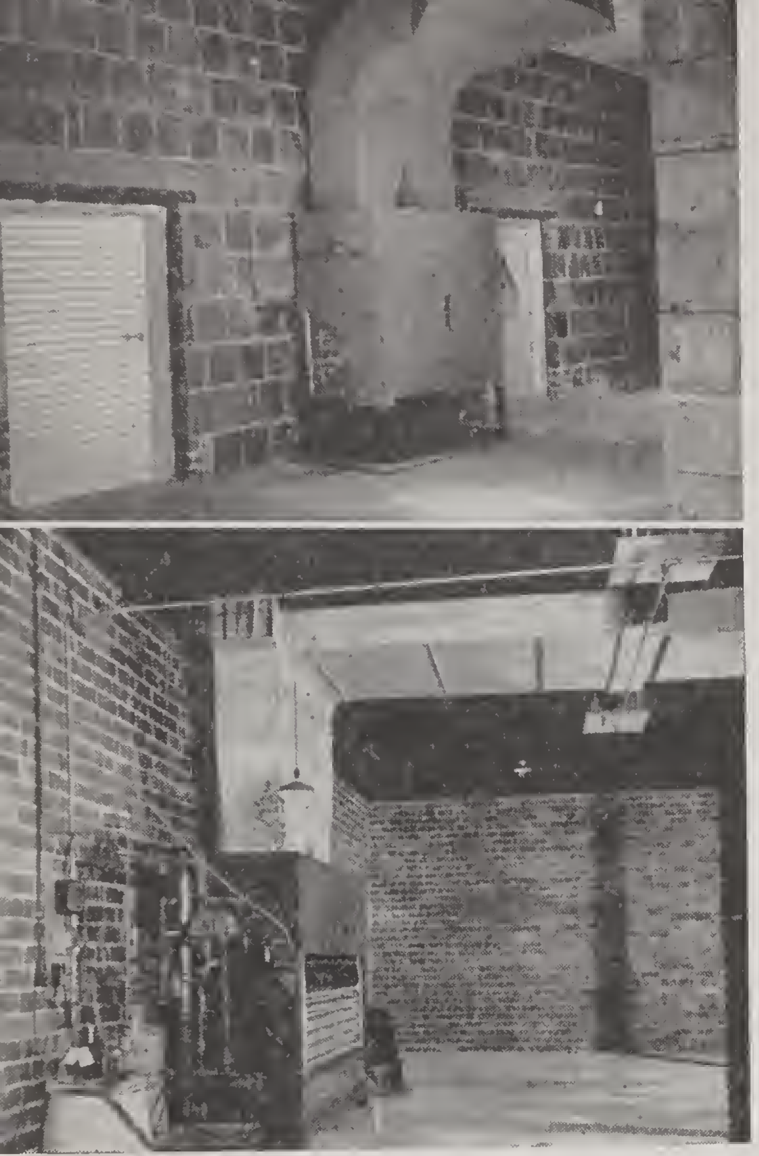
It is more economical to install two compressors than one of the same total capacity. The chief refrigeration load comes at harvest time. Considerably less refrigeration is needed once the products are cooled to the holding temperature. Thus, with two machines, one machine should be capable of producing about two-thirds of the total required refrigeration and the other producing the remaining one-third. Both machines will operate during the loading-in period, then perhaps the larger one can carry the load for a time, and eventually, the smaller one may provide the necessary refrigeration during the colder winter months. This arrangement is better and more economical than having one machine with a change of speed of operation according to load. The compressors are operated thermostatically on not more than a two-degree range in storage temperature.

Condensers. Purpose of a condenser is to absorb and dissipate the heat which the refrigerant picks up in the storage room. Two types are in use. In one type, a pipe is placed within a pipe with cool water running in the inner pipe and the refrigerant running in the outer pipe. This type of arrangement is usually mounted on the wall in the compressor room. In the other type of condenser, there is a series of coiling pipes within a large metal cylindrical shell. Water flows through the pipe and the refrigerant on the outside through the shell.

In farm storages, water is often scarce, in which case the warm water from the condenser is pumped to the outside (Figure 136) or to the roof, cooled by spraying it through spray nozzles into the air and then collecting it on the roof for reuse through the condenser. A certain amount of water needs to be added to the system continually because a portion is lost in evaporation.

Expansion coils. The coils in which the refrigerant evaporates or expands from liquid to gas may be either inside or outside the storage room. In what is known as the "brine system" the evaporating coils are usually outside of the storage room and emersed in a bath of saturated brine solution (calcium or sodium chloride). The brine is thus cooled and then circulated by pump into the storage room through coils. This method is used for cooling some commercial storages, but rarely used in farm storages. It has several disadvantages: (1) the numerous pipes in the storage room take up considerable space, (2) they require periodic defrosting, (3) are more expensive to install and operate, (4) the brine corrodes metals, and (5) most important, there tends to be too much temperature variation throughout the room. When an attempt is made to cool the fruit to 32° F. in the center of the room, fruit next to the coils may freeze. The chief advantage is the fact that there is no danger of injuring the fruit by excessive gas leaks.

With the "direct expansion" cooling units, the refrigerant flows into coils in contact with the storage room air where it expands into a gas and absorbs heat; no brine solution is involved. In recent designs the coils are concentrated into a small space and the air is moved rapidly through them by means of a high speed fan, as shown in Figure 141. This type of forced air circulation and refrigeration is widely used in farm storages. The warmer air enters the unit at the base, is sucked over the cooling coils, and blown out through the upper vents. The advantages of this system over numerous pipes along the walls or against the ceiling are (1) the air is moved rapidly throughout the room, avoiding "dead air" spaces, (2) the smaller amount of coil system can be defrosted easily at regular intervals, (3) considerably less space is occupied in the storage room by refrigeration equipment, (4) there is less trouble from storage diseases, such as brown core and internal breakdown, and (5) a uniform temperature is automatically maintained within a narrow range of 1° or 2° F.



(Top) Donald Comin, Ohio Agr. Exp. Sta. (Bottom) William Steuk, Venice, Ohio

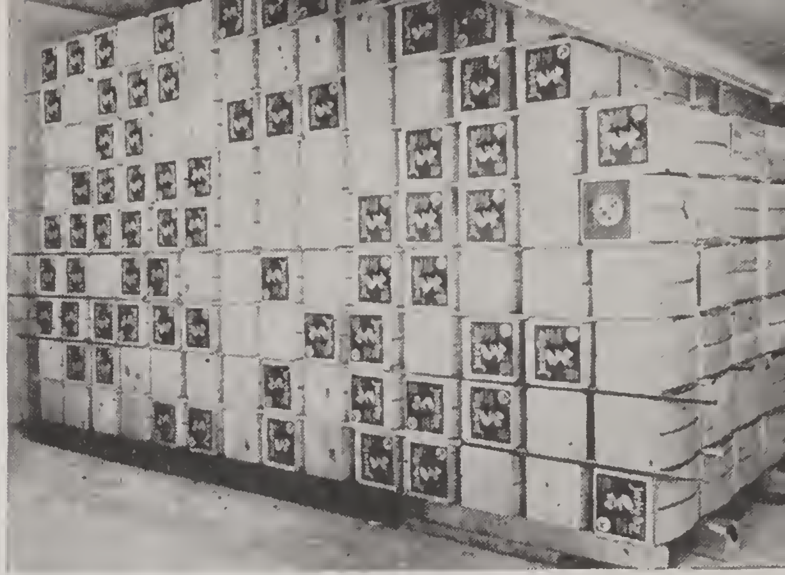
Figure 141. (Top) A cooling unit or evaporator installation in a 12,000 bushel refrigerated farm storage. Direct expansion coils are compacted in a cabinet equipped with blower fans; air enters at the base, exhausted at top. Air ducts are not necessary in storages 40 feet or less in length. (Bottom) Cooling unit with front removed showing refrigeration coils. Unit is equipped with air ducts for uniform distribution of cold air. Humidifying pipe system is shown near ceiling. Alleyways among stacked fruit should run at right angles to air flow.

There are two types of blower units, known as ceiling and floor types. Ceiling units are used in small storage rooms where only one or two units are needed. However, for large rooms, too much machinery is involved in ceiling units and the floor-type units are preferable. Floor units are used for individual storage rooms having a capacity of 3000 or 4000 to as high as 25,000 bushels.

The following precautions should be observed in arranging the floor unit, the air ducts, and the fruit containers in the storage: (1) A minimum of 12 inches should be allowed between the tops of the containers and the ceiling; this permits the air draft from the blower to continue over the fruit for the full length or width of the room; the cold air sifts down among the containers and is sucked back along the floor until it enters the base of the unit for recooling; (2) A four- to six-inch space should be provided between the containers and the wall opposite the unit; (3) Containers should be spaced about one to two inches apart and two to five inches from the floor, as shown in Figure 142; (4) Aisles or alleyways should not run parallel to the air flow because they provide flues and reduce air circulation among the stacks; if such alleyways are necessary, hang periodic heavy curtains across them to prevent flue action; (5) Alleyways which run at right angles to direction of air flow should be bridged across the top with wall boards or similar material; this prevents the air from short circuiting and developing dead-air spaces; and (6) If girders or beams are present on the ceiling, it is important that they run parallel to the air flow.

Air circulation. The fan in the floor unit should be large enough to move at least 100 cu.ft. per minute of air per ton of refrigeration. In other words, if the equipment is of five and one-half tons capacity, the fan should pass about 5,500 or more cu.ft. per minute.

Defrosting of floor units is necessary about once a day during the storage season and more often during the loading-in period. Collection of frost on the coils not only reduces air circulation through the closely spaced coils, but also interferes with heat transmission into the pipes. Defrosting can be accomplished by several methods: (1) passing hot refrigerant gas directly to and through the expansion or cooling coils; (2) shutting off the compressor and continuing to operate the fan when the storage temperature is 34° F. or higher; (3) drawing outside air over the coils by fan; (4) periodic spraying of water over the cooling coils, and (5) continuous spraying of brine water over the coils. With good machinery of correct design, the spraying of brine water (sodium chloride) seems to be the favorite system of defrosting blower units, although water spray is becoming increasingly popular.



California Fruit Exchange, Sacramento

Figure 142. Boxes of fruit should be stacked on their sides in the storage and separated so that cold air can circulate around each container. Note one-by-two-inch slats for separating boxes and steadying the piers. Some growers paint white three-inch stripes on the floor to facilitate box alignment. Auxiliary fans increase efficiency of cooling in this type of storage.

Humidity control. Moisture in the air must condense when the saturation or dew point (100 per cent relative humidity) is reached for a given air temperature. Thus, when air at 34° F. with a relative humidity of 88 per cent is cooled to 31° F. by coming into contact with refrigeration coils or wall surfaces, the saturation point of the atmosphere is reached; with further cooling, there is condensation of moisture on the walls or coils. Water so-collecting on the coils or walls and running out of the storage through drains must come indirectly from the stored apples or through the walls and ceiling, or from both sources. This moisture must be replaced, especially if it is coming from the fruit. Otherwise, the fruit will shrivel and lose weight. The wider the difference between the temperature of the air and the temperature of the walls or coils, the more the water condenses on the walls or collects on the coils in the form of frost. There should not be more than a 10° difference, and preferably less after the fruit is once cooled down, between the coil temperature and that of the air entering the cooling unit.

With proper operation and proper refrigeration equipment, it is possible to maintain a relative humidity in excess of 90 per cent. Under such conditions, fruit shriveling will not be perceptible. A simple humidifying or water atomizing apparatus which can be assembled by the grower is described by Comin in Ohio Bulletin 632. Assembled storage humidifiers are available on the market.

Surveys in Michigan, New York, Ohio, and Massachusetts have indicated that costs before World War II for constructing farm storages and equipping them with mechanical refrigeration has varied from 50 cents to $1.00 per bushel capacity, or, 20 to 40 cents per cubic foot. The average price is about 75 cents per bushel or 30 cents per cu.ft. According to Marshall, a conservative estimate of peacetime construction costs of farm storages with tile walls and adequate insulation, adequate refrigeration machinery, and a sorting and handling room of adequate dimensions would be 75 cents to $1.00 per bushel capacity. A little more than 50 per cent of this cost would probably be for construction of the building.

Electric consumption should be between one to one and one-half kilowatt hours per bushel per season. Assuming an average of three cents per kilowatt hour, cost of power should be about 3.5 cents per bushel per season for winter variety apples. Cost of loading and unloading the storage is about one cent per bushel. Total cost of operation of farm storages ranges between 10 to 20 cents per bushel for the season, with the average around 16 cents per bushel.

Cost of renting space in commercial cold storages varies. During the non-inflation period it has averaged about 20 cents per box or 25 cents per bushel basket until the first of April after which there is a five-cent additional charge per box or bushel per month.

Review Questions

1. What are the benefits to the grower of storing his fruit in (*a*) an air-cooled storage and (*b*) a refrigerated storage?
2. What effect does lowering the temperature from 50° to 40° and 40° to 32° F. have upon the rate of ripening of apples?
3. How does humidity affect stored apples; what relative humidities are recommended for an air-cooled storage and a refrigerated storage?
4. What is the value of ventilation in refrigerated storages?
5. How much space should be allowed for each bushel in calculating capacities for storage buildings?
6. List two popular insulation materials used in air-cooled and refrigerated storages and what respective thicknesses are recommended for side walls, floor, and ceiling.
7. What is a vapor barrier and where is it located in a refrigerated storage?
8. Why is floor insulation recommended in cold storages and left optional for air-cooled storages?
9. Briefly describe the operation of an air-cooled storage.
10. What factors must be known in estimating the refrigeration load for an apple storage?
11. Under average conditions, about how many tons of refrigeration should be provided for a 10,000 bushel farm storage?

12. List three refrigerants and give a disadvantage of each.
13. Trace the path of the refrigerant through the refrigeration system naming the important equipment involved.
14. What are the advantages of using the diffuser or blower system of cooling as compared with wall-type coils in the storage room?
15. What precautions should be taken in stacking apple boxes in a storage room cooled by a floor unit blower system?

Suggested Collateral Readings

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CHAPTER XII

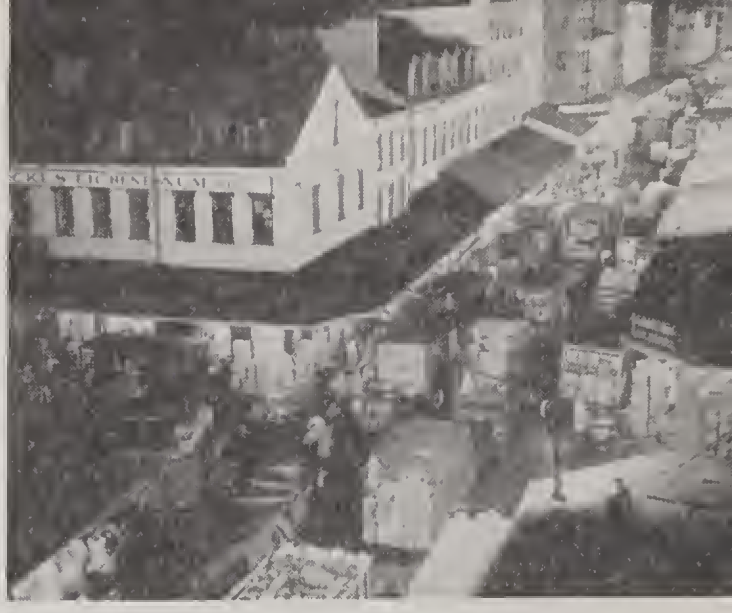
Marketing Apples

The first and most important step in marketing is to *grow superior fruit.* With a high-quality and attractively packaged product, a grower's marketing problem is more than half solved.

METHODS OF SELLING

Grower to retail buyer or consumer. The most simple and direct procedure in selling apples is where the grower deals directly with retail grocers, pie companies, and similar outlets in nearby towns and cities. As an example, an Ohio grower sells practically his entire crop of 65,000 bushels to trade in Cleveland, Youngstown, and neighboring cities. Apples are packed out of storage through the winter in fiberboard cartons, varying from one or two dozen apples to one bushel. The large trucks travel a set route once or twice a week in order to keep a fresh supply on hand at the regular clients. The young men in charge of these trucks and fruit sales are especially selected and serve, in addition, as managers of the cultural program for 50-acre blocks of the orchard. The trucks rarely travel to cities further than 100 miles.

Wholesale markets for growers. In major fruit and vegetable producing sections in the Middlewest and East, a number of wholesale markets for growers have developed. An example of one of the larger ones is at Benton Harbor, Michigan. In order to attract a sizable crowd of buyers, there must be a regular supply of quality produce available at these markets. Stocks for financing the establishment of the markets are purchased by growers and local business men. A system of long, narrow, open platforms, roofed for weather protection, are established in an ideally located distribution center. The growers must pay a small fee to park their loaded trucks next to the platforms where they display samples of produce for inspection by regular buyers visiting these markets. The Benton Harbor Fruit Market has buyers coming from as many as 29 states who deal directly with the farmers. Several buyers may contact a farmer before a final deal is registered. Once a deal is made, however, the farmer cannot withdraw to accept higher bids offered by other buyers. After the sales, the buyer may provide his own truck for returning the acquired produce, or in some cases, the truck belonging to the grower may make the delivery to the buyer's place of business.

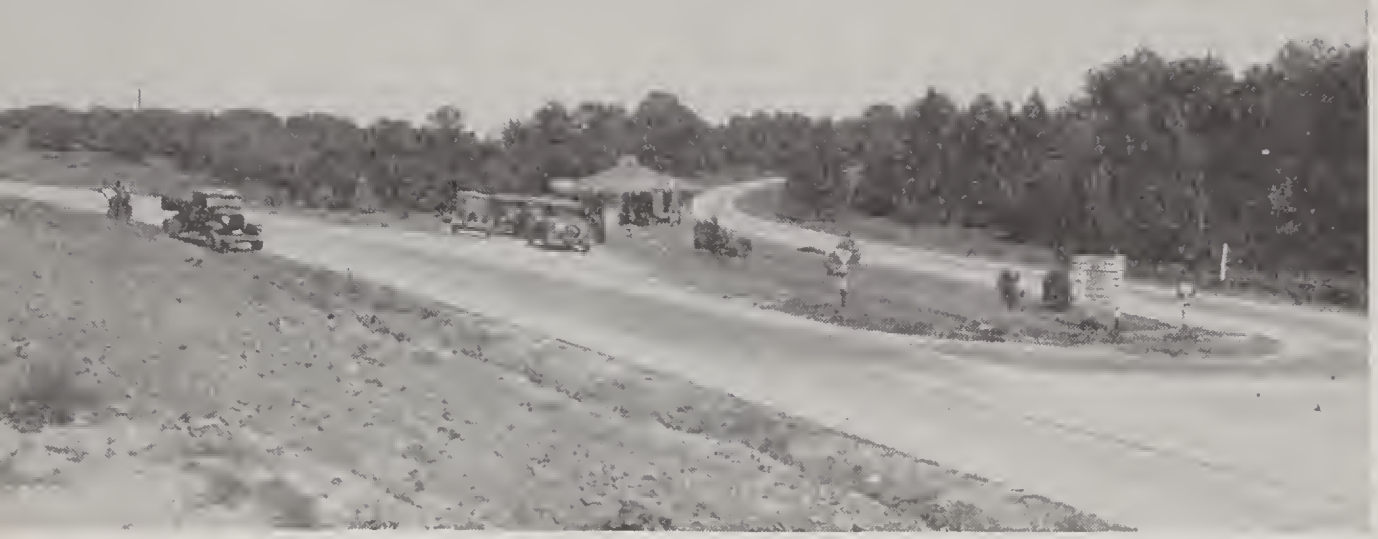


Time, Inc.

Figure 143. This is congested Washington street, heart of the lower west side Manhattan wholesale market for fruits and vegetables, New York City. Business is handled by commission, by outright purchase, and by joint account. Flash photograph was taken during early morning hours when incoming shipments were at a peak.

In recent years, the Benton Harbor Fruit Market has transacted an annual business totaling over five million dollars. Obviously, local business men, as well as farmers, are interested in these markets because they bring considerable money and business into the respective areas. After the establishment of the Benton Harbor Fruit Market in 1930, the neighboring fruit and vegetable industry showed a marked increase in acreage.

Co-operative selling. Co-operative selling is feasible where the apple industry is sufficiently concentrated as in the Northwest and the Shenandoah-Cumberland regions. The grower undoubtedly strengthens his position from a marketing standpoint by pooling his efforts with those of others engaged in the same business. There are many advantages in co-operative selling: (1) A standardized product can be offered; (2) The volume of products handled is sufficiently large to attract the larger regular buyers; it is difficult for an individual grower to supply sufficient repeat orders for the big buyers unless he is a large grower; (3) An association can keep in close contact with market conditions through their agents in the large buying centers (Figure 143); (4) Supplies and equipment can be purchased in wholesale lots at a considerable saving; and (5) An association can carry on extensive advertising and publicity campaigns which are denied an individual grower. It is for the latter reason that the large apple organizations in the Northwest have been so successful in moving enormous quantities of their product. Citrus organizations in California, Florida, and Texas have been even more successful in placing their products prominently in every hamlet in the country. Comparison between citrus growing and apple growing, however, is not entirely safe because of the extreme centralization of the citrus producing areas, making co-operative organizations comparatively simple.



A. M. Musser, Clemson Agricultural College

Figure 144. A large volume of business is transacted at this roadside fruit market, ideally located at the intersection of two main highways in South Carolina. Adequate parking space is available. Fresh fruits, fruit ice creams, and cold drinks are featured .

Roadside marketing. On well-traveled highways, usually near large cities, there is a good supplemental sales outlet for fruit by roadside marketing. The peak sales occur during the summer months of July, August, and September. Most patrons are from the middle and better classes who buy primarily to obtain fresh and better quality produce. Second-grade goods can be sold for canning and cooking in rather large quantities if properly priced; low-grade or cull products should not be offered. A fair price at the roadside market is one somewhat below city retail price for the same grade. This is because the grower has relatively less overhead and no delivery charges.

Saturdays, Sundays, and holidays are the best days between the hours of 2 and 5 P.M. Largest purchases are from motorists returning home. Motorists leaving the city usually buy only for consumption that day. A market located next to the in-coming lane of traffic to a city will often do twice the business of a market located near the out-going lane. The sales building should be neat, clean, orderly, but not necessarily expensively built. Adequate parking spaces on one or both sides of the road are of paramount importance. Attractive, concise, easily understood signs should be used for advertising the market; they should be placed at an angle to the road, legible at 150 feet or more, and far enough from the stand to give the driver ample opportunity to stop. Salesmen must be courteous, accommodating, and always attendant, making every effort to develop return sales.

Using marketing agencies. A knowledge of market customs, market procedure and market conditions is of considerable importance to the grower. All of the marketing steps, whether performed by the grower or some other agency, represent a definite service rendered and entail an unavoidable cost. The steps are as follows: (1) assembling the fruit at a local packing or shipping point, (2) grading, standardizing, and packing, (3) transporting, carting, and delivering, (4) storing and warehousing, (5) disseminating fruit at wholesale and terminal markets, (6) financing the transactions and assumption of risks, and (7) final distribution to the consumer.

The grower may avoid all of the above steps except the first and second and sometimes these also. The intermediate buyer of the fruit assumes most of the marketing risks and, therefore, he seeks to protect himself by a wide margin of safety in prices. The more of the above steps for which the grower assumes responsibility, the greater the possibility of increased financial reward to him. Most large growers, however, as well as co-operative packing associations usually sell their fruit through a commission house or broker. This indicates that there is a point in the marketing process at which it is desirable for a special agency closely in touch with market affairs to take over responsibility.

Commission house. When the fruit reaches its destination, it is often handled by a *commission house* which provides inspection for the fruit on arrival, pays transportation charges, cartage, storage charges if any, negotiates the sale, collects the money, and deducts all charges plus a commission of 7 to 10 per cent of the gross sale, depending upon the size of the transaction. Net returns from the sales are then sent to the shipper. For the protection of shippers, some states maintain a list of bonded and licensed commissioned merchants. Growers should consult this list before establishing a connection.

Jobber. A jobber is a person who purchases large quantities of fruit from the commission houses, or direct from the grower. The jobber may buy with a definite outlet in mind or he may take a chance on matching his knowledge and experience against the "ups and downs" of the market. He may gain or lose heavily.

Broker. A broker merely acts as a contact man between the seller and the buyer. The broker deals in carlot quantities, but seldom has the goods in his possession. The seller usually contacts his broker, giving him the grade and other details of his products; the broker then seeks a buyer among his friends in the trade. He wires the best deal he can secure to the seller for his acceptance or rejection. If the deal is accepted by the seller, the broker executes a sales contract, the product is supplied to the buyer, the broker retains his fee which is about half the usual commission charges, and returns the net cash to the grower. The grower should select his broker with great care, making certain that he is of established reputation. There is an advantage of dealing with a reputable broker because the grower can retain the fruit in his possession until he is ready to sell. Thus, the grower has more control over the sale than when he consigns it to a commission house.

Disposal by auction. The principal items sold at large fruit auctions are citrus, northwest apples, California grapes, and Pacific Coast pears. The boxes of fruit are available for inspection on platforms or piers prior to and during the auction (Figure 145). The contents of each lot are listed on sheets available to all persons attending. Prospective buyers make hurried inspections and mark their lists to indicate on which items they will consider making bids. These lists are closely watched as the auction proceeds.

The auctioneer conducts the sale from a high rostrum so that he may see everyone and all may see him. The seller may withdraw his offering under prescribed conditions, but he may not bid himself. The fruit is available for immediate delivery and the auctions are usually finished by midafternoon. The principal fruit auctions in the United States are the following:

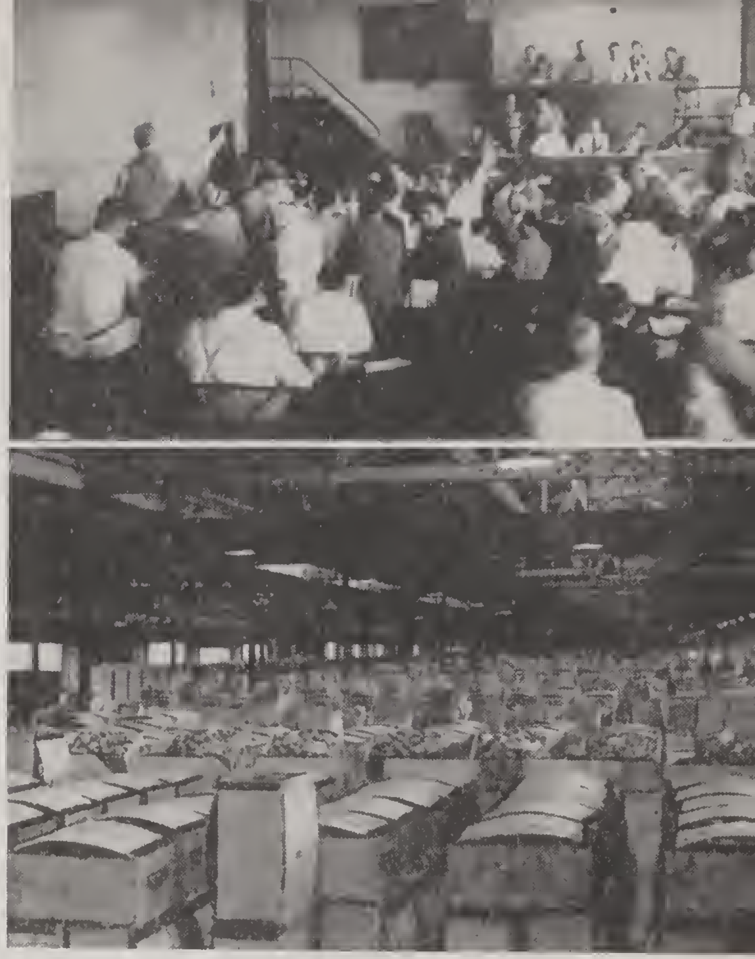
New York Fruit Auction Corp., New York City
Brown and Seccomb Fruit Auction Co., Inc., New York City
H. Harris & Co., Boston
Philadelphia Terminals Auction Co., Philadelphia
Baltimore Fruit Exchange, Baltimore
Union Fruit Auction Co., Pittsburgh
Consolidated Fruit Exchange, Cleveland
United Fruit Auction Co., Cincinnati.
Detroit Fruit Auction Co., Detroit
American Central Fruit Auction Co., St. Louis
Fruit Auction Sales Co., Chicago

The majority of the above firms are members of the American Fruit and Produce Auction Association, Inc., 66 Harrison St., New York City. This group handles an annual business valued at over $130,000,000. The buyers represent wholesale grocers, restaurants, chain stores, hotels, or brokers. The smaller lots may be taken by hucksters, and push cart men. The usual auction commission is 2½ to 3½ per cent on standard products in quantity.

In dealing through auction, the shipment is usually consigned to a commission agent or to some representative of the shipper who makes contacts with the auction company. In this transaction, the commission agent's charge is less since the auction company does the selling. Auction companies deal almost entirely with well-known and firmly standardized brands of products. Competition is usually keen enough to eliminate unfair practices. The auction method of selling is continuing as one of the most popular systems of selling fruit. Auctions also are used extensively in Europe during normal peace times.

SHIPPING POINT INSPECTION

In addition to a government Inspection Certificate on grade, pack, quality, and shipping condition at point of origin, there is also provided by state or government officials an Inspection Certificate of the fruit upon arrival at the destination. The certificates of these inspectors are accepted in the courts of the United States as *prima facie* evidence of the truth of the statements therein contained and is the standard recognized basis for the buyer's final acceptance of quality, grade, pack, and condition. This service encourages greater care on the part of shipping concerns; it also reduces the rejection of cars at a destination because of trivial reasons when the market is oversupplied. The inspection system induces stability and general confidence in the market; it is the best kind of insurance that the shipper can buy. The cost is between $8.00 and $10.00 per car. Further information regarding this inspection service can be obtained from The Farm Products Inspection Service, Production and Marketing Administration, U. S. Department of Agriculture or from the local state departments of agriculture.



W. C. Crow, U.S.D.A.

Figure 145. (Top) Auctions offer a rapid, convenient means of disposal of large quantities of fruit. (Bottom) A fruit auction display house in Chicago where prospective buyers first examine the various lots of fruit, take notes on a published catalog giving essential information regarding the fruit, and then proceed to an auction room for the bidding where selling proceeds item by item.

The Federal Inspection Service also issues a "Condition Report" upon request. This covers such factors as decay and other deterioration in a product which does not affect its established grade. It is usually requested after storage. Before storage, for example, apples could be graded Extra Fancy and be within the established tolerance for decay at time of storage. Later, if decay developed to an excessive amount, they would still be Extra Fancy, but out-of-condition because of decay, and the "Condition Report" would so certify.

MARKET PREFERENCES

It is general knowledge among fruit growers that some varieties are in greater demand in some cities than in others; also, that some cities are better markets for second-class fruits than others. Some orchardists consider Pittsburgh a good market for second-grade fruit, due probably to the large population of foreign workers in the mills, mines, and factories. Midwestern cities such as Kansas City, Fort Worth, and Omaha have often paid higher prices for a given pack and variety than large eastern cities, including Chicago. An eastern grower must first consider freight rates, handling, and cartage charges before shipping his fruit to the midwestern markets. Unless the price received would compensate for these additional charges and also add a profit, there would be little or no reason, other than gluts on the eastern markets, to warrant sending fruit to the Midwest.

Freight on apples shipped by standard ventilation may vary somewhat from period to period. Approximate cost of shipment from Washington or Oregon to New York City is 75 cents per box of apples; from Hancock, Maryland in the Shenandoah-Cumberland region, 16½ cents; from Winchester, Virginia, 17 cents; and from Albion, New York, 16 cents. Refrigeration adds about 15 per cent to these rates on long hauls and up to 50 per cent on short hauls. It is apparent that the Pacific Coast region is under a definite handicap in shipment to all points East. None but their best fruit can be shipped these long distances at a profit.

LOADING AND SHIPPING FRUIT

The first requirement in shipping fruit successfully is to use rigid containers and pack them firmly. Containers must be stacked solidly against the car walls and against each other; ventilation should be provided in all parts of the car and throughout the stacked fruit. Packages which are defective in any way should not be loaded because the collapse of one such package may cause the entire load to shift, resulting in considerable damage to a large portion of the shipment. Any railroad over which fruit is shipped will furnish complete directions for loading of boxes, baskets, or barrels.

If the fruit has set outside over night, it should be loaded early in the morning while it is cool. If it has been in cold storage, so much the better. It may take several days to properly cool fruit that is warm when placed in refrigerated cars or trucks. Fruit near the top and in the center of the car requires much longer to cool in ice-refrigerated cars. If the temperature of the fruit is 75° to 80° F. when loaded, it may take 12 hours for it to reach 45° F. in the bottom layer and six or seven days for fruit in the top layer to reach 50° F. Obviously, considerable ripening can occur in this time and shorten the future storage life of the apples. Rapid precooling of fruit in special storage rooms or with portable machinery temporarily attached to the loaded car is frequently practiced with West Coast apples. The mechanics of precooling is discussed in the chapter concerning peaches with which crop it is of paramount importance.

Loading wooden boxes. The number of containers loaded in a railroad car will vary, but the standard carload for both domestic and export shipment consists of 798 western boxes; a load may vary from a minimum of 630 to a maximum of 854, obtained in a solid through load. Carload freight rates from production districts to the seaboard cannot be protected for a lesser quantity than 640 boxes. Rail freight rates covering quantities less than carloads are prohibitively high, in which case, shipment by refrigerated motor trucks might be advisable.

In a car of 756 boxes, wood car strips one-half-inch thick and eight feet long are used crosswise on the third, fifth and sixth layers, each box being nailed at opposite corners to the strips to keep the load in good alignment and to prevent shifting. The strips also keep the boxes apart for air circulation. In cars consisting of 630 boxes, car strips are used only on the third and fifth layers (boxes being piled five high). Boxes must be stacked on their sides to prevent bruising the fruit.

Carload shipments from the Northwest are loaded solid throughout or with a standard type "A" center gate approximately 30 to 36 inches wide. The purpose of this gate is to tighten the load and provide better air circulation from the ice bunkers at the end of the cars or from the heaters to prevent freezing. From Idaho, a wedge-type of center gate is frequently used.

In other parts of the United States where the Eastern box is used (17 by 14 by 11 inches), the usual carload consists of about 500 boxes loaded 6 wide, 4 high, and 21 long. The boxes are placed top up and not stacked on their sides. The wood car strips are nailed on top of each layer of boxes and each end of every box. Where the width of the refrigerator car will permit, an air channel of approximately two inches wide is left between rows of boxes. These air channels extend from one end of the car to the other. Railroad inspectors for perishable freight state that about half of the cars are loaded solidly from end to end of the car without a center gate. A bulkhead is used at one end to fill the fractional space, if any. The other 50 per cent of the carload shipment of apples in the Eastern type of box is loaded with the standard type "A" center gate. The space occupied by the center gate makes it necessary to add an additional layer of boxes near one end of the car with the usual type of step-load bracing.

When wood boxes, 16 by 13½ by 11½ inches are used in the midwestern states, a carload usually consists of about 630 boxes.

Loading corrugated boxes. The cell-type corrugated boxes are frequently used in shipment from the northwest and northcentral states. These boxes are loaded direct from cold storage in solid carload lots and not mingled with wood boxes containing other varieties. All boxes are piled lengthwise except a few rows in the center of the car where the boxes are sometimes placed crosswise to completely fill the available space and thereby eliminate the need for a bulkhead at one end. It is not possible to nail wood strips on corrugated boxes in order to separate the boxes and provide air channels for ventilation. However, by using corrugated spacing blocks, an open type of load can be secured without any nailing.

A large Eastern shipper who has for several years used corrugated boxes holding eight consumer units of the corrugated-tray type has reported good success without employing any special method of loading. A shipper using this type of container can easily secure a tight load because each load consists of an assortment of box sizes. The shipments are made in refrigerator cars in order to protect the apples from freezing. It is reported that carloads of Golden Delicious apples from the Northwest in cell-packed corrugated boxes have arrived in severe cold weather without damage due to freezing on days when freezing claims on other apples were a common occurrence.

Loading baskets. In the packing of bushel baskets, the covers should be fastened at four points. All baskets should be loaded with covers up, and except for the bottom baskets, each basket must rest midway upon two baskets below. Alternate rows in a layer are placed half a basket-diameter from the end of the car. This offset arrangement provides a fairly compact load of 528 baskets loaded six wide and four high, solid from one end of the car to the other. Summer varieties of apples ship better if loaded only three high. The baskets are set so the handles are diagonal to the length of the car. Each row of baskets, four high, should be completed before starting the next row. Rows are worked back and forth the full length of the car. The last two rows near the door are loaded together, starting from each end of the car and working toward the center until the doorway is snugly filled.

Manner of shipment. Many apples are shipped long distances to market and frequently are in transit from one to three weeks before being unloaded. There are several services by which fruit can be shipped as outlined below. The service selected should depend upon the variety of apple, the condition of the fruit, the time it will be held in storage before selling to ultimate consumers, weather conditions, the time of year shipped, the character and facilities of the railroad or steam ship and the probable length of the trip. Because of the long distances and varying conditions, it is always best to deal with reputable firms and leave the choice of shipping service to them. Most shipments today are being made under refrigeration. The United States Government maintains a daily broadcast of weather reports. The use of these reports is invaluable in determining the type of shipping services which should be used.

Under American railway tariff regulations, fruit can be shipped under the following services.

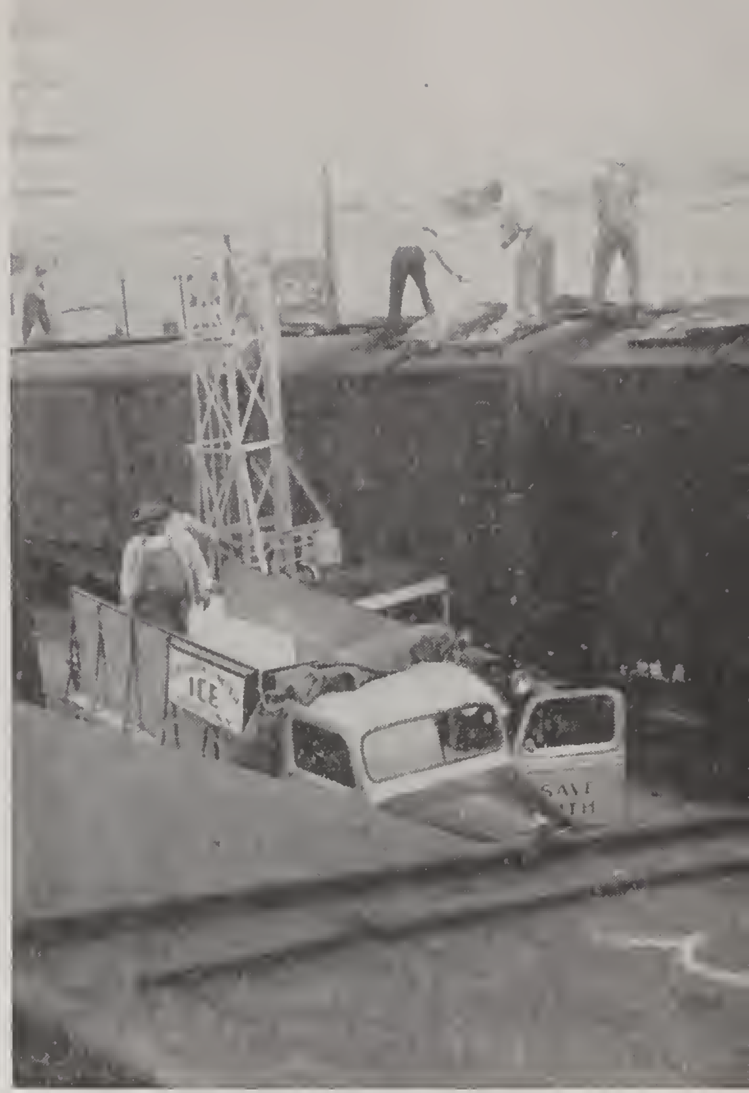
1. **Standard refrigeration.** This means protective service against heat by the use of ice placed in the refrigerator car bunkers (Figure 146). The insulated cars carry from 6,000 to 12,000 pounds of ice. Under standard refrigeration, the cars are re-iced to capacity by railways at all regular icing stations, or at approximately 24-hour intervals while in transit from point of shipment to destination.

2. **Standard refrigeration with salt.** This service is the same as outlined above, except that about 3 per cent of salt is included at each icing station at an added cost. The salt affords more intensive refrigeration and lower temperatures inside the car, and is suggested for fruit loaded warm which will be commercially stored at destination for several months.

3. **Initial icing only.** Under this service, the railways furnish refrigerator cars with ice tanks filled to capacity at the time of shipment, but no further ice is furnished. This service is often used with fruit coming from cold storage or which has been precooled for shipment.

There is a modification of this service known as initial icing with one or two re-icings in transit, which means that the cars are iced to capacity at point of origin and re-iced to capacity at a designated point in transit. Both, or either of these services also can be safely used with winter varieties of apples being shipped during early fall or early spring when the requirement for ice in shipment is not so great.

In early fall months when warm weather periods are likely to occur during shipments destined for the Atlantic Seaboard for trans-shipment, it is advisable to use "standard refrigeration" or "standard refrigeration with salt," particularly on such fall varieties as Winter Banana, King David, Jonathan, Delicious, McIntosh, Stayman Winesap, Rome Beauty, and Spitzenberg. "Initial ice" or "initial ice with one re-icing in transit" can safely be used on these varieties during late fall or early spring months.



H. A. Cardinell, Michigan Exp. Sta.

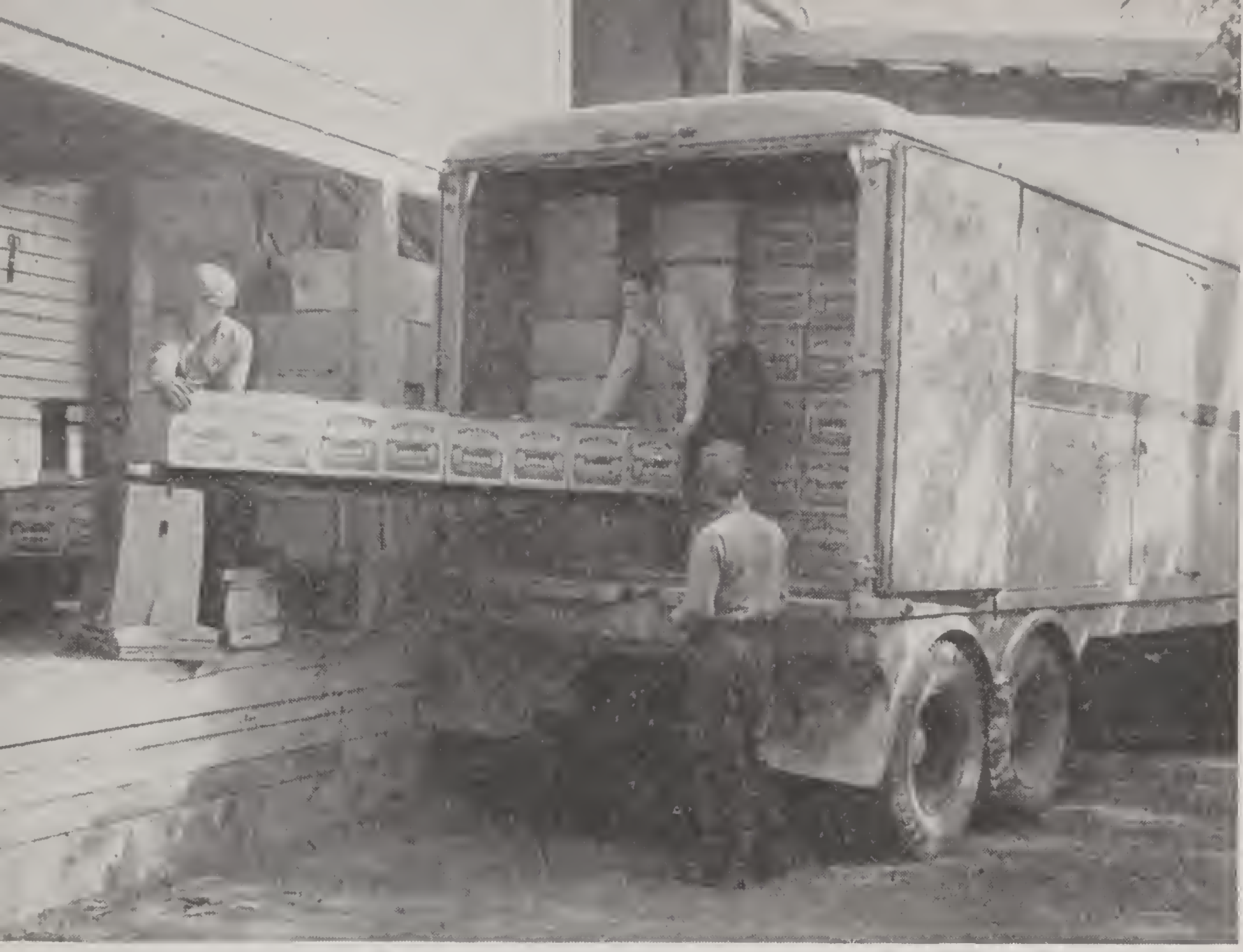
Figure 146. Refrigerator cars loaded with fruit are iced at point of origin. Escalator mounted on truck lifts ice from another truck to bunkers in the cars. The ice is "barred down" with heavy iron bars to fill air spaces. About 3 per cent salt may or may not be added, according to the type of service specified.

4. Ventilation service. This is the cheapest service available to the grower and should be used only when the fruit will be sold for immediate consumption. Under ventilation service, the fruit is carried in refrigerator cars without ice. The hatch covers and plugs are manipulated so as to exclude or admit outside air according to prevailing temperatures. Fruit coming out of cold storage preferably should be shipped under refrigeration, and if this is not feasible, it should go as described under "b" below to retain its cold as much as possible.

Cars may be shipped under "ventilation service" as follows: (*a*) Standard ventilation with all ventilating devices open when temperatures rise above 32° F. and closed when temperatures fall below 32° F.; (*b*) vents closed and plugs in to final destination regardless of the weather; and (*c*) vents open, plugs out to final destination regardless of weather.

"Special ventilation service" means manipulation of hatch covers and plugs so as to admit outside air when temperatures range between 32° and 45° F., and exclude outside air when temperatures are lower than 32° F. and higher that 45° F.

5. Box car service. Box cars are used only in case of extreme emergency



C. E. Chase, Washington State Apple Adv. Commission

Figure 147. Refrigerated trucks and trailers offer convenient, rapid, and less expensive means of shipment for the relatively short hauls. Distance of truck shipments are usually less than 250 miles from point of origin, although some shipments are made regularly a distance of 400 miles or more. Although these boxes have high cleats at either end for fruit protection, it is wise to handle boxes on their sides.

when there is a refrigerator car shortage. Box cars are risky because they have no insulation and no provision for ventilation.

6. Carriers protective service against cold. During the period October 15 to April 15, inclusive, shipments may also be made under this service. The railways will protect the shipment against frost, freezing, or artificial overheating by charcoal or by special burners during subfreezing weather. (There is a great need today for thermostatically controlled heaters with forced air circulation. With heaters commonly used, the temperature in the top layers may be 60° F., while that in the lower layer is almost freezing. Undoubtedly, considerable damage has been done to Delicious by overheating in the top layers under this service.) The service extends to the Atlantic seaboard.

Use of trucks. In the last several years, the use of trucks for shipment of fruit has increased tremendously. Trucks are mostly used for hauls of less than 250 miles. They are invaluable for transporting fruit to and from wholesale markets in congested areas. The principal advantages of the motor truck are speedier service, less expense, and less handling. Some of these trucks are equipped with refrigerator service for the longer hauls, as shown in Figure 147. Some disadvantages have arisen with the use of motor trucks, but measures are being taken to correct them. Among the disadvantages are the following:

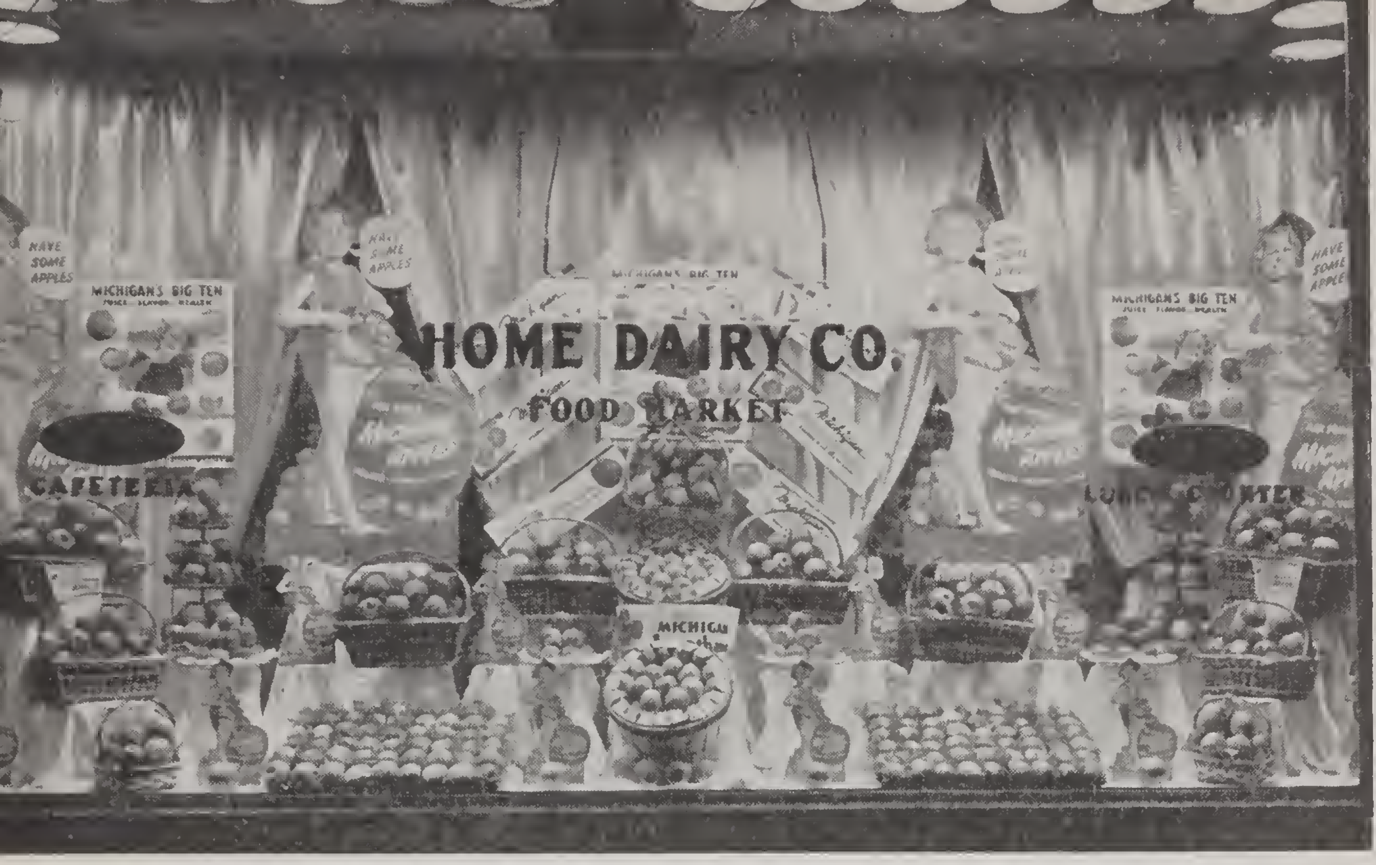
1. Inadequate terminal facilities for handling produce arriving by motor truck.
2. Variation from one state to the next in motor-vehicle laws.
3. Lack of good salesmanship and knowledge of market procedures on the part of the grower or truck driver.
4. Lack of systematic control of movement of the trucks to market.
5. Inadequate advance knowledge of market supplies by both the grower and terminal operators.

By railroad shipment, the market knows when cars leave their shipping point and approximately what time they will arrive at their destination. Thus, the market can be operated in a systematic manner. With motor trucks, however, the market is often unaware of the number of trucks leaving fruit farms. Obviously, during some periods an excessive amount of produce may arrive by motor truck, causing a drastic fall in market prices. This situation is being corrected by the organization of farmers' co-operative associations at country shipping points, which act as a medium for notifying the large markets of the arrival of a definite amount of produce at a definite time.

IMPROVING THE SELLING AND ADVERTISING PROGRAMS

People normally eat about the same amount of fruit from one year to the next. If consumption of one fruit is increased by intelligent and persistent promotion, consumption of another fruit must suffer. In recent years, the sales of citrus fruit have been increased to such an extent that apple sales have been adversely affected. The popularity of citrus is unquestionably due to extensive advertising programs to make the housewives conscious of the health values of citrus.

Promotional organizations. In order for apple sales to keep pace with competitive fruits, it has been necessary for special organizations to devote more and more time and money to extensive advertising programs. Among the groups which have played a major and highly effective part in these programs are the *Washington State Apple Advertising Commission, Appalachian Apple Service, Inc., International Apple Association, National Apple Institute, Pacific Northwest Fruit, Inc., Michigan State Apple Commission, California Fruit Exchange,* and several other state and regional organizations. Channels of promotion consist of advertising in leading national newspapers and magazines, outdoor posters, radio programs, moving pictures, advertisements directed to the produce and retail grocery trade, direct messages to the



Minard Farley, Jr., Michigan State Apple Commission

Figure 148. An attractive window display during apple promotion week in Michigan. This display is well balanced, neither scanty nor overdone, instructive as to uses of different varieties, and, finally, it creates a real appetite for apples.

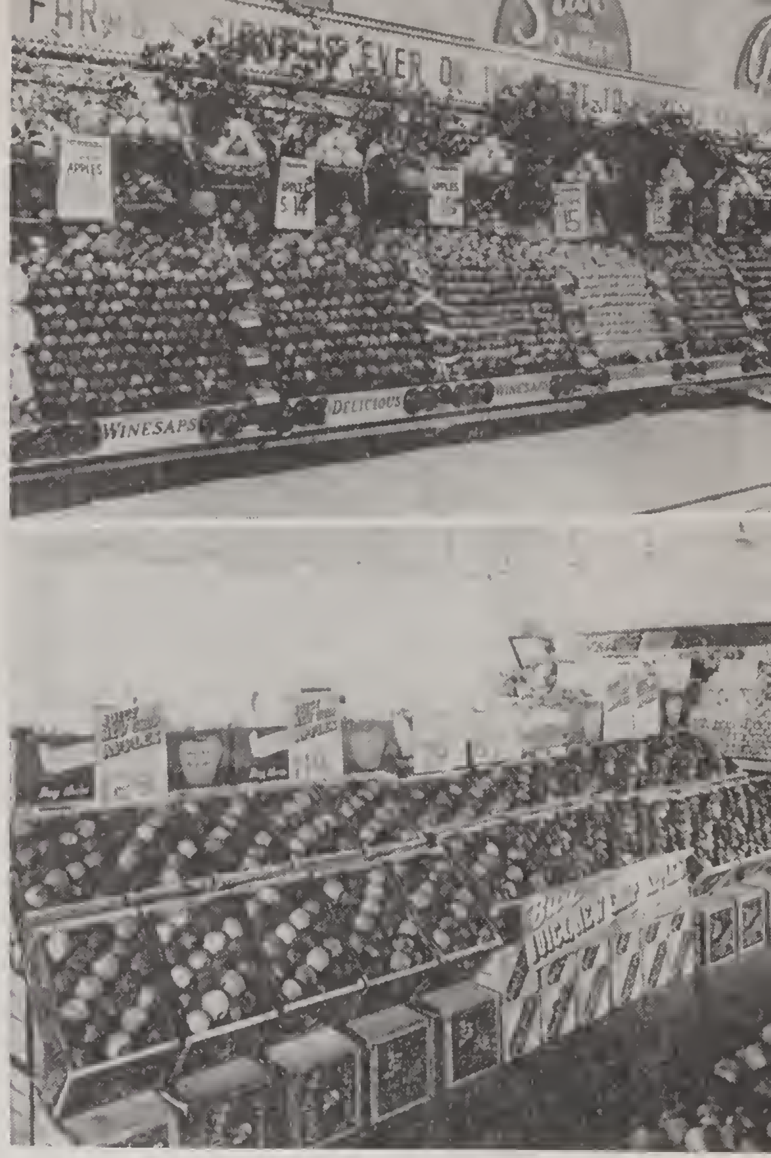
trade by telegram and special bulletins, store display material sent to the trade upon request, apple books containing pertinent information of varietal and cooking uses, and "tie-in" advertising with other lines of food such as breakfast foods, cigarettes, and cooking recipes.

The *International Apple Association* is composed of growers, exhibitors, and distributors. This is the principal apple organization operating on a nationwide basis in the United States. It deals with practically every phase of the apple industry, but the major emphasis is placed upon distribution. State and regional meetings on promotional problems are arranged for leaders of the industry. Headquarters are at Rochester, New York. The *National Apple Institute* in Washington, D. C., has been in operation for several years. It consists largely of growers who pay an annual membership fee and receive frequent notices as to market trends and developments. This organization sponsors research and education in apple selling and also assists in promotional activities, such as "tie-in" advertising of the apple with as many other foods as possible.

Many of the above organizations have special year-round representatives boosting the sales of apples in cooking schools, assisting in retailer education in setting up displays, and properly handling apples for the best sales possible (Figures 148, 149). It is to the advantage of every grower to support one or more of these organizations . Some states, including Washington and Michigan, have passed laws which place a tax upon every bushel of apples produced and sold in their states. Revenue from this tax is used for the promotion of apple sales.

Boosting retail sales. Several pointers and suggestions have been made for increasing sales once the apples reach the retailer. A number of the suggestions by the National Container Association are as follows:

1. There must be a co-ordinated program of advertising and selling efforts; high-quality, well-packed fruits must be available in sufficient quantities to back up the advertising program. If any one step in a promotional program breaks down, the entire program is liable to collapse.
2. Most fruit sales in retail stores are made on Wednesday, Friday, and Saturday with Saturday accounting for 35 to 50 per cent of the total weekly sales. Afternoon sales are greater than morning sales.
3. The housewife buys 80 per cent of the food for the table. She buys largely through her eyes by "impulse sales." If the apples have been carefully handled and packed, properly priced, and attractively displayed by a retail store, they are more than half sold to her.



(Top) Appalachian Apple Service, Martinsburg, Va.
(Bottom) R. J. Barnett, Kansas Agr. Exp. Sta.

Figure 149. Massive displays of apples are very effective in increasing sales during big promotional periods. Only the big chain stores and large grocers who serve thousands of people can afford to boost apples on this scale. All such promotions must be backed by co-ordinated intelligent selling and advertising and by adequate quantities of *high-quality* stock.

4. A survey showed that 30 per cent of 443,000 grocery and combination grocery stores in the United States does 80 per cent of the business in fresh fruits and vegetables. It was found wise to concentrate promotional efforts and activities on this 30-per cent group of stores which are in a position to influence a greater proportion of the nation's housewives.
5. There is no more potent advertising of apples than a beautiful display of fruit itself, particularly when a display is backed up by aggressive, intelligent selling, and an adequate supply of high-quality fruit.
6. The better displays are artistic, clean, well lighted, have an appealing color arrangement, have clearly readable variety, grade and price tags, and are well stocked and full-looking at all times. Items closely associated with apples on menus should be included in the display when available.
7. The larger apples of a variety bring the quicker sales and better profit.

Faced apples (red side out) may sell three times faster and bring gross profits four times as great than jumble pack. Good appearance of apples with no bruising is a tremendous factor in boosting sales. Quality and condition of apples are more important than price in sales of best grades of apples.

8. The grocer might figure an average shrinkage loss of about 5 per cent. Although this figure is bound to vary under different conditions, the grocer in pricing his fruit at the outset should figure on this handling loss in order to roughly compensate for it.

9. The grocer should check his display frequently and sort out apples beginning to fade or show signs of deterioration. These should be sold immediately at marked-down prices before the fruits are a complete loss.

10. If possible, the clerks should receive special training in the proper handling of apples. They should also be informed on the many uses for the different varieties of apples so that they can provide helpful suggestions to the housewives for apple preparations. Often this instruction can be obtained for sizable groups of clerks and store operators through the local state agricultural extension service or through special apple promotional organizations.

11. The National Container Association recommends small consumer cartons containing two to five pounds of apples. They are especially convenient for rapid sales. The top layer should be clearly evident and open for inspection. These cartons save the grocer the time and trouble of placing the apples in a paper sack. Also, the buyers do not finger the apples so much and bruise them with their thumbs. With these consumer packs, it has been found that there is little or no leftover fruit of poor quality.

12. The chart shown in Figure 150, or a similar one bearing information on local varieties, is valuable to both retailers and consumers in selling and buying wisely. They should be placed prominently near the display counters.

13. The health value of apples should be stressed in posters and in discussing apples with the housewife. Apples supply carbohydrates and minerals in the diet and have important therapeutic values. In institutions for the care of children in both Europe and America, remarkable relief of digestive troubles, including diarrhea, dysentery, enteritis, and dyspepsia has been reported. The number of patients was large and the controls adequate. Scraped or pulped apples and apple powder are used for children to cleanse and detoxify the intestines.

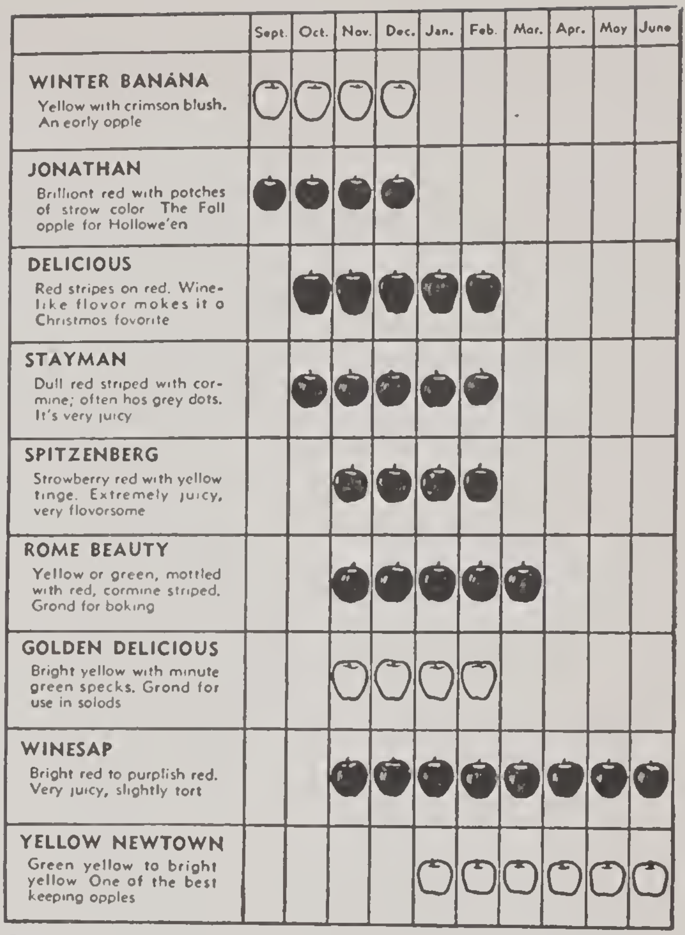
14. A small inexpensive folder provided either by the grocer, distributor or retailer, is effective when placed in each package, giving details regarding uses for varieties, a few cooking recipes, health value, and better methods for keeping apples in the home (Figure 150).

15. Provisions for cold storage of apples in the retail store are highly desirable for preserving quality and condition of the fruit. Otherwise, if possible, the retailer should buy from a jobber or seller every two or three days to keep a fresh supply coming from a local commercial cold storage.

16. Among the fruits found in American markets, the *apple* is one of the easiest to handle. If properly packed and handled, it can go through the

merchandising channels with the least loss of all fruits.

By-products. About one-fourth of the total apple crop of the United States is processed into by-products. The greater percentage is canned, largely as apple sauce. Dried apples constitute about 7,000,000 bushels a year, and during World War II this figure was greatly exceeded because dried apples afforded a convenient means of handling under adverse conditions. Frozen apples have taken a definite place among the by-products, amounting to around 2,000,000 bushels a year. Other by-products of apples consist of cider, vinegar, dried cubed apple breakfast food, apple concentrate, apple powder, and apple pumice. Apple sirup has been found valuable in retaining quality and moisture in white breads, cigarettes, and smoking tobacco. The U. S. Department of Agriculture Eastern Regional Research Laboratory at Upper Darby, Pennsylvania, and another in California are devoting considerable time to a study of new uses for by-products of fruits. Definite steps are being made in this field for better utilization of culls and low-grade fruit which are definitely receiving less and less sympathy in the fresh fruit marketing channels.



	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June
WINTER BANANA Yellow with crimson blush. An early apple	○	○	○	○						
JONATHAN Brilliant red with patches of straw color. The Fall apple for Hallowe'en	●	●	●	●						
DELICIOUS Red stripes on red. Wine-like flavor makes it a Christmas favorite		●	●	●	●	●				
STAYMAN Dull red striped with carmine; often has grey dots. It's very juicy		●	●	●	●	●				
SPITZENBERG Strawberry red with yellow tinge. Extremely juicy, very flavorsome			●	●	●	●				
ROME BEAUTY Yellow or green, mottled with red, carmine striped. Grand for baking			●	●	●	●	●			
GOLDEN DELICIOUS Bright yellow with minute green specks. Grand for use in salads			○	○	○	○				
WINESAP Bright red to purplish red. Very juicy, slightly tart			●	●	●	●	●	●	●	●
YELLOW NEWTOWN Green yellow to bright yellow. One of the best keeping apples					○	○	○	○	○	○

C. E. Chase, Washington State Apple Adv. Commisison

Figure 150. Chart published in color by the Washington State Apple Advertising Commission and distributed as an aid to retailers and consumers in moving Washington apple varieties in their proper season. Similar information for other districts on basis of local varieties could be stamped on corrugated boxes or printed on folders containing other pertinent information, and dropped in each container or sack of purchased apples.

EXPORT MARKETS

Although the proportion of the total crop absorbed by the export market is not great, it is of considerable importance to the American growers. Normally, prewar exports accounted for from 10 to 15 per cent of the total commercial apple crop. In some recent years, it may have exceeded this percentage because of the large quantity of food exported to relieve the food situation in war-torn foreign countries.

The trend of apple exports in the years following World War II is difficult to predict. Sooner or later, however, they will probably follow more or less the same prewar pattern of distribution. In normal times, the amount of apples exported from the United States varies with the size of the European crop, particularly in England, and the size of the Canadian crop; most of the Canadian exports are sent to England. Although Canada and Mexico are stable export customers, most of the United States trade goes to the British Isles and its possessions with fair quantities going to Germany, the Netherlands, Belgium, France, Denmark, Argentina, Brazil, Philippine Islands, and others. Germany and the Netherlands also serve as distributing centers for United States shipments to neighboring territories. Ports of export from the United States are Boston, New York, Philadelphia, Norfolk, Baltimore, Seattle, San Francisco, Portland, Maine, and Portland, Oregon. In Canada, Halifax is the chief port with Montreal, Quebec, and St. Johns in the East, and Vancouver on the Pacific Coast, making shipments.

Chief export varieties are those of firm texture and relatively long storage life, including York Imperial, Yellow Newtown, Winesap, and Rome Beauty. Other varieties are shipped in lesser quantity; tender varieties, such as McIntosh, require very careful packing and handling for export.

Export requirements. Only standard grades and varieties are desired. The smaller sizes are in demand. Fruits for export must be firm and tightly packed and handled almost entirely by refrigeration in shipment and in storage. The export markets desire a steady, uniform, dependable supply of good fruit, honestly packed. The practice of dumping on European markets the poor grades which will not sell elsewhere has been the chief obstacle to enlargement of export demand.

Selling methods for export. Shipment may be consigned to reputable European firms, or, f.o.b. sales may be made to representatives of foreign buyers. Much of the fruit is sold on the foreign market by auction.

Review Questions

1. List the advantages of co-operative selling of apples. Under what conditions can this system of selling be best executed?
2. Briefly describe a well-operated roadside market for fruit.
3. How do the following marketing agents or agencies operate in disposal of fruit: commission house, jobber, broker, and auctions?
4. What is the value of shipping point inspection?
5. Describe the procedure for loading Western wooden apple boxes into a refrigerator car.
6. What is meant by shipment with "standard refrigeration"?
7. What part does the motor truck play in the transporting and marketing of fruit?
8. List 3 apple promotional organizations and state how they are aiding in disposal of apples and other deciduous fruits.
9. List 6 suggestions for increasing apple sales in retail stores.
10. How important are by-products in the utilization of apples? List the principal apple by-products.

11. In normal peacetime, what percentage of the total commercial apple crop is exported? List 5 leading countries utilizing apple exports from the United States.

Suggested Collateral Readings

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CHAPTER XIII

Pear and Quince Culture

PEAR CULTURE

The earliest authentic record of pears in the United States is probably that of the Endicott pear tree planted near Salem, Massachusetts, about 1830. It was brought to America by the French and English colonists. Despite the early introduction and general popularity of pears, they have never become as widely grown as the apple in America. Commercial production of pears is largely limited to favored areas west of the Rocky Mountains, principally in California, Washington, and Oregon. Most of the expansion in pear growing since 1920 has been in these three Pacific Coast states where the conditions are favorable to economical and heavy production of high-quality fruit. In fact, this region is the most highly commercialized pear-growing section in the world. It contributes about 70 per cent of the United States pear supply.

Pear production in the eastern United States is of little commercial importance, except for a few regions around the Great Lakes. Production is largely limited to home orchards and for local consumption. In many ways, the pear is more desirable for home orchards than the apple because it grows and fruits better under neglect. Also, pear trees are relatively long-lived. Once a tree has become mature and well established, it may live and produce satisfactorily for 100 years or more.

Pear psylla and fire blight were largely responsible for a marked decrease in pear trees in the East from 1910 to 1930. Since 1930, this reduction has been less marked. It is doubtful if commercial pear production in the East will ever show a marked increase until an economically effective measure is devised for controlling blight. This disease is favored by the high humidity and warm temperatures which often accompany early spring weather in the East.

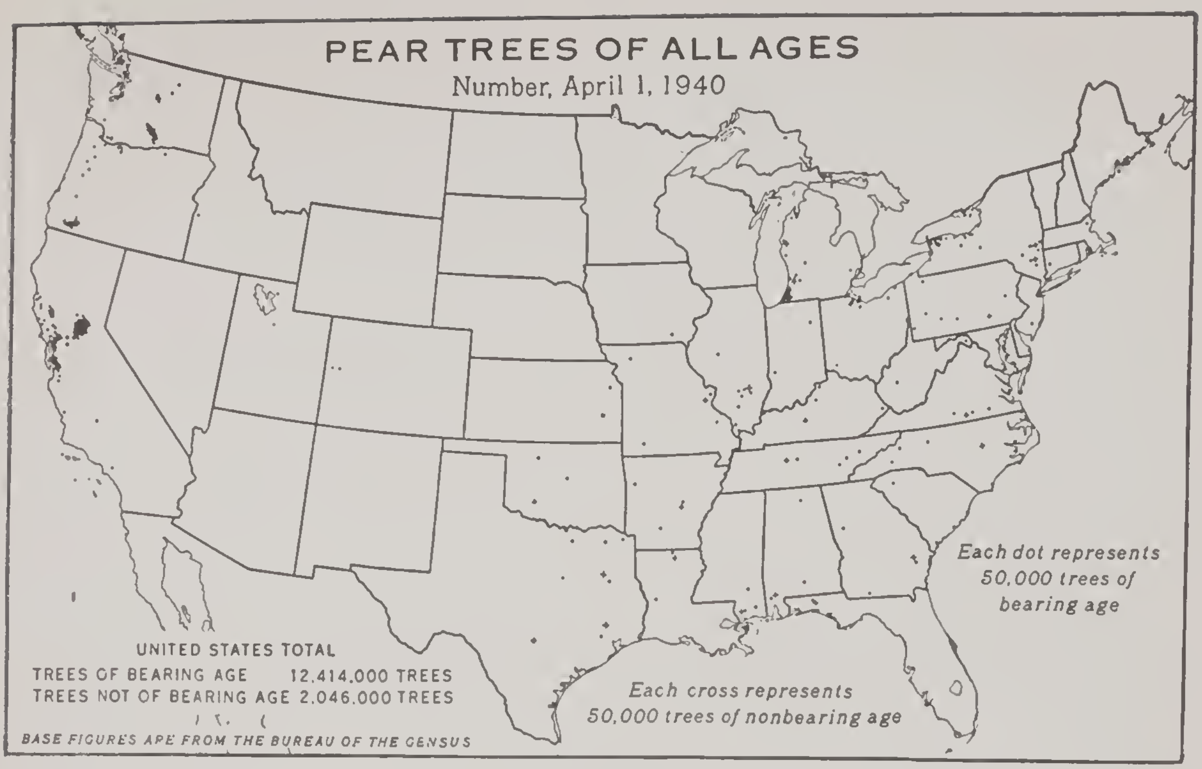

PEAR TREES OF ALL AGES
Number, April 1, 1940
Each dot represents 50,000 trees of bearing age
UNITED STATES TOTAL
TREES OF BEARING AGE 12,414,000 TREES
TREES NOT OF BEARING AGE 2,046,000 TREES
Each cross represents 50,000 trees of nonbearing age
BASE FIGURES ARE FROM THE BUREAU OF THE CENSUS

Figure 151. From 1929 to 1940, pear trees of all ages in the United States decreased 32 per cent. This decrease was largely in states east of the Rocky Mountains. Most expansion in pear growing since 1919 has been in areas west of the Rocky Mountains. The later 1945 Census showed 13,875,766 pear trees of all ages in the United States, a further decrease in numbers.

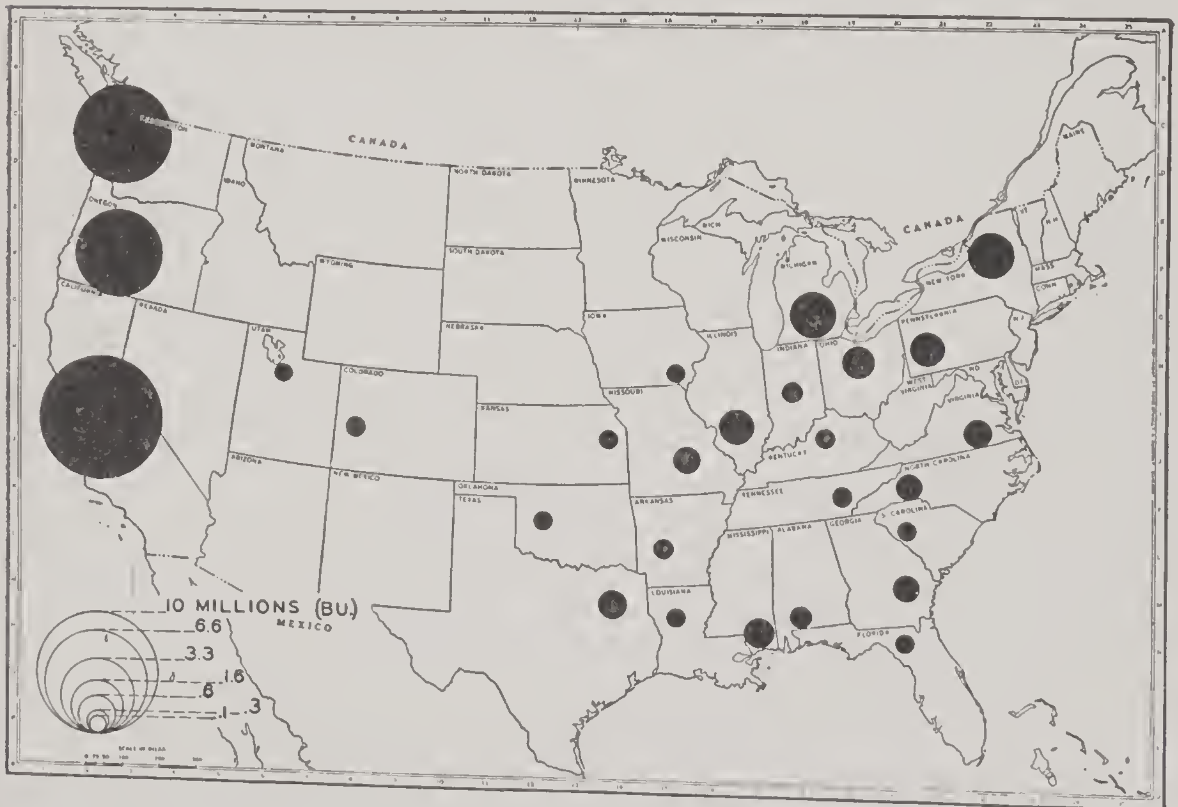


Figure 152. The chart shows relative pear production by states, 1938 to 1947, inclusive. The average United States commercial pear production during this period was about 30 million bushels annually. Leading states of California, Washington, and Oregon produced about 70 per cent of the total crop, three-fourths of which were of the Bartlett variety.

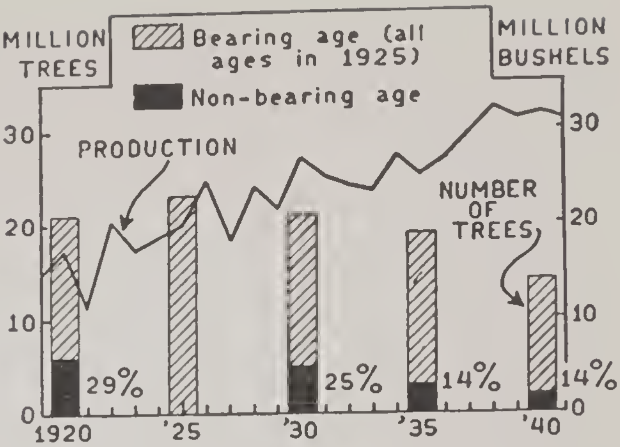
Figure 151 shows the distribution of pear trees in the United States according to the 1940 Census. Total number of bearing trees was 12,414,000 and of nonbearing trees—2,046,000 trees. The number of pear trees of all ages in the United States decreased 32 per cent between 1929 and 1940. Pear trees of bearing age decreased 33 per cent and those of nonbearing age decreased 61 per cent. As indicated above, these reductions in pear trees have largely been east of the Rocky Mountains.

In contrast to the above reduction in tree numbers, pear production has nearly doubled in the United States during the past 20 years, the increase having largely occurred in the Pacific Coast states (Figure 153). According to the U. S. Census of 1939, the pear crop of that year was 35 per cent greater than in 1929. The 1936–45 ten-year average production in the United States was 29,510,000 bushels, of which California was responsible for about one-third. Leading states showed the following production and rank: California, 10,751,000 bushels; Washington, 6,780,000 bushels; Oregon, 4,074,000 bushels; Michigan, 976,000 bushels; and New York, 975,000 bushels. All other states produced less than 600,000 bushels, as indicated in Figure 152. Pears averaged about 8 per cent of the noncitrus fruit production between 1934–43. Fresh sales comprised a little more than half the production, pears canned about a third, dried about 3½ per cent, and other disposition, including farm use, about 10 per cent.

Commercial pear production on the Pacific Coast is largely confined to nine districts. Progressing from north to south in Figure 151, these districts are the Wenatchee and Yakima Valley areas in central Washington; the Hood River Valley in northcentral Oregon, and the Rogue River Valley around Medford in southern Oregon; in California, the foothill district of Eldorado, Placer, and Nevada counties, the Sacramento River district, the coast district north of San Francisco Bay, that district south of the Bay generally known as the Santa Clara Valley district, and the southern California acreage mostly in the Antelope Valley in Los Angeles County, the latter of which is decreasing in commercial importance.

Pears rank third among the most important tree fruits grown in the world and fourth among all fruits for which statistics are available. World pear production in the 1930's averaged approximately four million short tons a year, which was approximately 6 per cent of the estimated world production of all fruits for all uses. Pear production is largely confined to areas within the temperate zone. France leads in production, followed in rank by the United States and Germany. Much of the pear crop in Europe is used for pear cider, whereas in the United States pears are mostly eaten fresh with lesser quantities canned and dried.

Argentina and the British dominions of Australia, South Africa, and New Zealand also produce pears largely for dessert and cooking. Pear production in these southern hemisphere countries has been increasing rapidly since 1930; from February to June, their exports are beginning to dominate the world's best export market—the United Kingdom. Fortunately, this season is opposite that of the West Coast harvesting and distribution season which occurs from June to September.



T. E. LaMont and H. F. DeGraff, Cornell University

Figure 153. Pear production in the United States doubled from 1920 to 1940, while the total number of trees showed a definite decline.

CHOICE OF PEAR VARIETIES

Pear varieties have a great diversity in size, shape, texture, and flavor. Pear species vary from the small hard inedible fruits of the Oriental pear, *Pyrus Calleryana Dec.*, to the fine-quality fruits of some varieties of the common European pear, *Pyrus communis L.* Also, there may be a considerable variation in fruit quality and shape within a variety from one region to the next. The Bartlett in Washington, for example, is longer and more narrow than in California, but it seems to attain higher quality where the summers are relatively hot than where they are cool.

All important pear varieties grown in the United States belong to the European species, except for a few hybrids such as Kieffer, LeConte, and Garber which are crosses between the European and the Japanese pear, *Pyrus serotina Rehd.* Although there are more than 2500 minor varieties and 100 major varieties, commercial pear production is limited to a relatively few varieties. In California, there are about 15 varieties with most of the acreage confined to six; a similar varietal situation exists in Washington and Oregon. The Bartlett variety accounts for about three-quarters of the United States commercial pear production. This is because the Bartlett fruit is well suited for canning, drying, and for fresh sales either locally or distant. The tree is also widely adapted to soil and climatic conditions. According to the ten-year average for 1936–45, the ratio of Bartlett pear production to production by other varieties in California was over eight to one; in Washington, about two and one-half to one; whereas in Oregon, slightly less Bartletts were grown than all other varieties combined. In 1945,[1] 44,374 acres of pears were grown in California of which 39,098 acres were devoted to Bartlett, 2,108 to Beurré[2] Hardy, 990 to Winter Nelis, 893 to Beurré Bosc, 773 to Doyenné du Comice,[2] 366 to Beurré d' Anjou, and 1,198 to other varieties.

In Washington, commercial varieties other than Bartlett are Anjou, Bosc, Winter Nelis, Comice, and Flemish Beauty. Two varieties are showing a decline in popularity; namely, Flemish Beauty as a result of relatively low quality and Winter Nelis because the fruit is not particularly attractive. In central Washington, Bosc does not attain the attractive cinnamon russeting desired by the trade. Anjou variety is showing consistent gains in popularity and constitutes most winter-pear shipments from Washington.

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[1] Acreage estimates from the California Co-operative Crop Reporting Service of the California fruit and nut crop as of 1945.

[2] The "Beurré" and "Doyenné du" are rarely used by growers. Pear varieties carrying these names are referred to as "Hardy," "Comice," or "Bosc."

In Oregon, Bartlett, Anjou, and Bosc are the most extensively planted varieties. Winter Nelis, Comice, Howell, and a few minor varieties are grown in commercial quantities, also, and range in importance in about the order named. Bartlett leads and along with Anjou has comprised the largest recent plantings. Although the Bosc bears large quantities of high-quality fruit in Oregon, it blights badly. Anjou is increasing in popularity and may exceed Bartlett because of its excellent size, appearance, and dessert and storage qualities. It is also the most blight resistant of the varieties extensively grown. The chief disadvantages of Anjou are lateness in coming into bearing, and somewhat less productiveness as compared with Bartlett and Bosc. Winter Nelis is satisfactory in Oregon when planted on deep well-irrigated soils; otherwise, the fruit may tend to run small in size.

The Comice attains high quality on the West Coast and has been extensively used in prepared gift packages in recent years.

The Kieffer variety is most generally grown in the East. Although the variety is of inferior quality, it produces heavily, and the fruit is an attractive deep yellow. The tree is widely adapted to soil and climatic conditions and is hardier and more blight resistant than other varieties grown in the East. Michigan and New York, the two most important commercial pear producing states in the East, and possibly Pennsylvania, are the only eastern states in which the Bartlett acreage generally exceeds that of Kieffer. Other commercial varieties are Clapp Favorite, Howell, Flemish Beauty, Bosc, Clairgeau, Seckel, Duchess d' Angouleme, and Anjou. New varieties which are being tried in the East and Northwest are Ovid, Early Seckel, and Gorham. Ovid is of higher quality and of more attractive appearance than Comice. Ovid resembles Bartlett in appearance but has patches of russet over the surface. It is one of the best winter pears. Early Seckel ripens about two to three weeks earlier than the Seckel of which it is a seedling and which it otherwise resembles. The Gorham ripens about two weeks later than Bartlett, and appears to be about equal in blight susceptibility.

In the southern states, such as Texas, the Kieffer, Bartlett, and Garber are the most popular varieties.

PEAR POLLINATION

From a commercial standpoint, all varieties of the European pear and hybrids such as Kieffer and Garber (*P. communis* × *P. serotina*) are self-unfruitful. In California, Bartlett varies in its pollination requirements from one section to another, being more or less self-unfruitful in the foothill section, whereas in the Sacramento River section, it sets satisfactory crops in most years in the absence of other varieties. Usually, however, the set does not exceed 1 to 3 per cent. In California, Comice, Flemish Beauty, Hardy, and Howell are said to be self-fertile varieties, but even with these varieties, they probably should be interplanted for highest yields.

In the United States, no commercially important varieties have completely infertile pollen. The less-important varieties with infertile pollen are largely triploid in number of chromosomes; namely, Alexander Lucas, Amanlis, Diel, Catillac, Boussock, Marguerité Marillat (diploid), Pitmaston Duchess, Pound, and Vicar of Wakefield. The following varieties are cross incompatible because of close relationship: (Female parents listed first) Bartlett × Louise Bonne de Jersey and the reciprocal, Seckel × Bartlett and the reciprocal, Seckel × Louise Bonne de Jersey and the reciprocal, Belle Lucrative × Seckel and the reciprocal, Belle Lucrative × Louise Bonne de Jersey and the reciprocal.

For such midseason blooming varieties as Bartlett, Bosc, and Gorham, both early- and late-blooming varieties should be intermixed. Early-blooming varieties include Keiffer, Howell, LeConte, Duchess d'Angoulême, and Anjou. Late-blooming varieties are Wilder and Winter Nelis and should be used only with midseason-blooming varieties.

Most pear varieties come into bearing about the same time, but some varieties such as Bosc, Seckel, and Cayuga may produce the first flowers from one to three years after Bartlett begins to bear, in which case the introduction of bouquets may be necessary during this period for these combinations.

Susceptibility to fire blight must be considered in selecting a pollinizing variety in pear orchards. Varieties such as Bosc, Clapp Favorite, Flemish Beauty, and Gorham, which are relatively blight susceptible, may be of little value as pollinizers after a blight attack, necessitating the use of bouquets for several years until blooming returns. Experience has shown that where a minimum number of trees are required as pollinizers for a Bartlett planting, it might be well to use some trees of a blight resistant variety as Old Home or of the relatively light bearing Anjou variety. One tree in nine is the minimum number of a pollinizing variety that can be used for successful crossing.

It has been observed that the honeybee prefers flowers of other fruits to those of the pear. For this reason, it becomes necessary to make every precaution to insure a thorough cross-pollination. An abundance of bees should be supplied, and interplanting of varieties arranged so that a pollinizing variety will be next to each tree requiring cross-pollination.

Hand-pollination has been practiced successfully in western states with pear varieties planted in large solid blocks. The commercial trials in general, however, have not been as successful as with apples. Detail directions for hand-pollination of pears are given by Overholser et al in Washington Popular Bulletin 174.

LOCATING THE PEAR ORCHARD

Climate. Pears require about 900 to 1000 hours of chilling below 45° F. during winter in order to properly break their rest period. This is about the same amount of chilling as required for the average apple variety, except for Bartlett which requires somewhat more chilling. In the southern United States and southern California, this is a factor to be considered. The uneven opening of flowers in spring due to insufficient winter chilling makes it difficult to properly time the sprays for codling moth, increases difficulty in controlling fire blight during bloom, and may interfere with cross-pollination in districts where it is needed.

Most pear varieties, properly matured, will endure winter temperatures as low as —20° F. without serious injury. Flemish Beauty, Anjou, and Clapp Favorite are the most resistant to cold; Bartlett is the least. Pear buds and wood are less resistant to cold than those of the apple but more resistant than the peach. Pear planting is generally questionable in regions where temperatures may fall lower than —20° to —25° F.

Although pear blossoms open earlier than apples and later than almonds, apricots, or peaches, spring frosts are a definite factor, and the selection of a frost-free site is important. Artificial heating of pear orchards is economically questionable and not common. Frosts during blossoming may also hinder cross-pollination.

The pear will withstand higher summer temperatures than the apple. As stated previously, Bartlett attains highest quality where summers are hot. In cool areas, Bartlett ripens unevenly and the core tissues tend to break down before the outside of the fruit is ready for use. For this reason, Bartletts from the hotter sections on the West Coast are largely shipped for eating fresh, whereas those in the cooler sections are canned or dried.

Water supply. Although pear trees are remarkably tolerant to drought or excessive moisture for relatively long periods, better and bigger crops can be obtained by special attention to irrigation and drainage. The marginal orchard suffers first from underconsumption or overproduction; availability of water may mean the difference between profit or loss. Better fruit size can be obtained in most commercial pear regions in the West by irrigation during periods of low rainfall. Irrigation may not be necessary on deep moisture-retentive soils which receive an abundance of winter rainfall.

Soil. Pears will grow in a wider variety of soils and will probably do better on the heavier wet soils than almost any other fruit. However, the pear performs best on a soil that approaches the ideal fruit soil—deep, fertile, well drained, easily worked, and not too heavy. In the West, freedom from alkali is important.

Transportation and packing facilities. If pears are to be shipped fresh, it is well to consider where they will be washed, graded, packed, and loaded for shipment. The nearer the orchard is located to these facilities, the better. Distance from these areas means additional hauling expense, extra jolting of the fruit, and extra delay before the ripening processes can be slowed down by cooling. These same suggestions hold for pears to be canned in local canning factories.

In view of the fact that most fresh pears are shipped East for consumption, the commercial grower must consider the type of competition these fruits may meet on the Eastern market, especially with plums, fresh peaches, and melons from the South during midseason, and with pears from other areas later in the season.

SITE PREPARATION AND PLANTING

In the West Coast and regions where irrigation is practiced, it is important to properly grade the slopes to conform with the irrigation system and to facilitate water distribution. Land should not be scraped, however, in some areas to such an extent that infertile spots are exposed. The square system is commonly used for planting trees in the West, spacing the trees from 16 to 24 feet apart. Orchards planted a distance of 20 to 22 feet have produced from 12 to 20 tons per acre. One orchard in California, planted 18 feet apart by the triangle method, yielded as high as 45 tons of marketable fruit per acre.

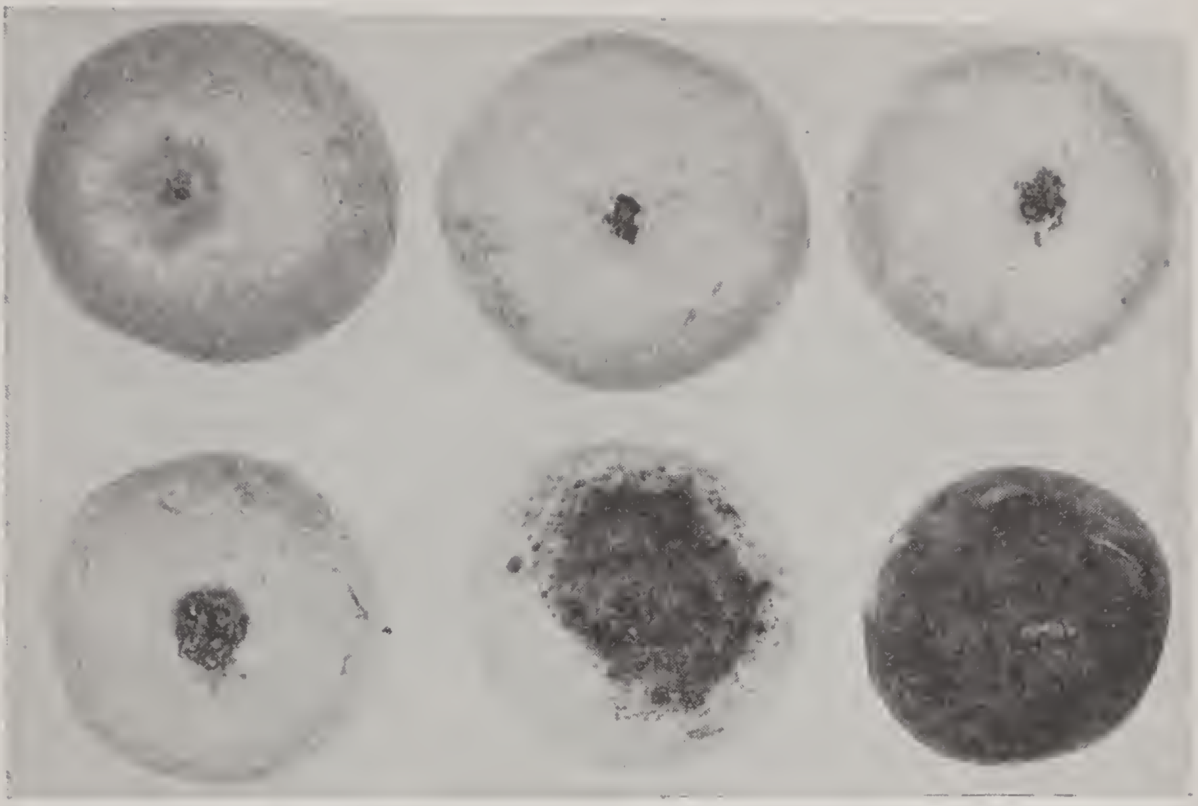
PROPAGATION AND ROOT STOCKS

The most widely used understock for pears is the European or French pear seedling (*Pyrus communis L.*). Preceding World War II, much of the seed was obtained from France and was removed from pomace of fruits of the European varieties, or from the Perry or cider pear (*P. nivalis Jacq.*). The seeds are now largely obtained from core waste of Bartlett pears from the canneries in the United States. In addition to Bartlett, seeds from fruit of Winter Nelis, Anjou, Hardy, and other pear varieties are used by nurserymen for pear understocks. Bartlett seedlings do not sucker badly, whereas those of Winter Nelis tend to produce many suckers.

Understocks of French or European pear seedlings, although relatively susceptible to blight, appear to be the best understocks now available for general planting. They are being used almost exclusive of the other rootstocks. The seedlings grow vigorously, withstand droughts and excessive soil moisture well, are highly resistant to mushroom root rot (*Armillaria Mellea* (*Fries*) *quelet*), but susceptible to leaf blight (*Fabraea maculata* (*Lev.*) *Atk.*), and are adapted to a wide range of soil and climatic conditions.

Rootstocks of the Japanese pear (*P. serotina Rehd.*) are largely being discontinued because they are unsatisfactory on heavy, wet, and shallow soils. Pear trees growing on this stock often develop physiological troubles known as "black end" or "hard end" (Figure 154), especially the Bartlett variety, which has resulted in great losses to orchardists. The understock does have the advantages, however, of being resistant to pear blight and wooly aphis, and it does not as a rule develop suckers. The latter characteristic can be used to roughly identify Japanese stock in the orchard in comparison with the European stock.

Other pear understocks of the Oriental type have been used, such as the Calleryana pear which is blight resistant and may have some possibilities.



L. D. Davis, University of California

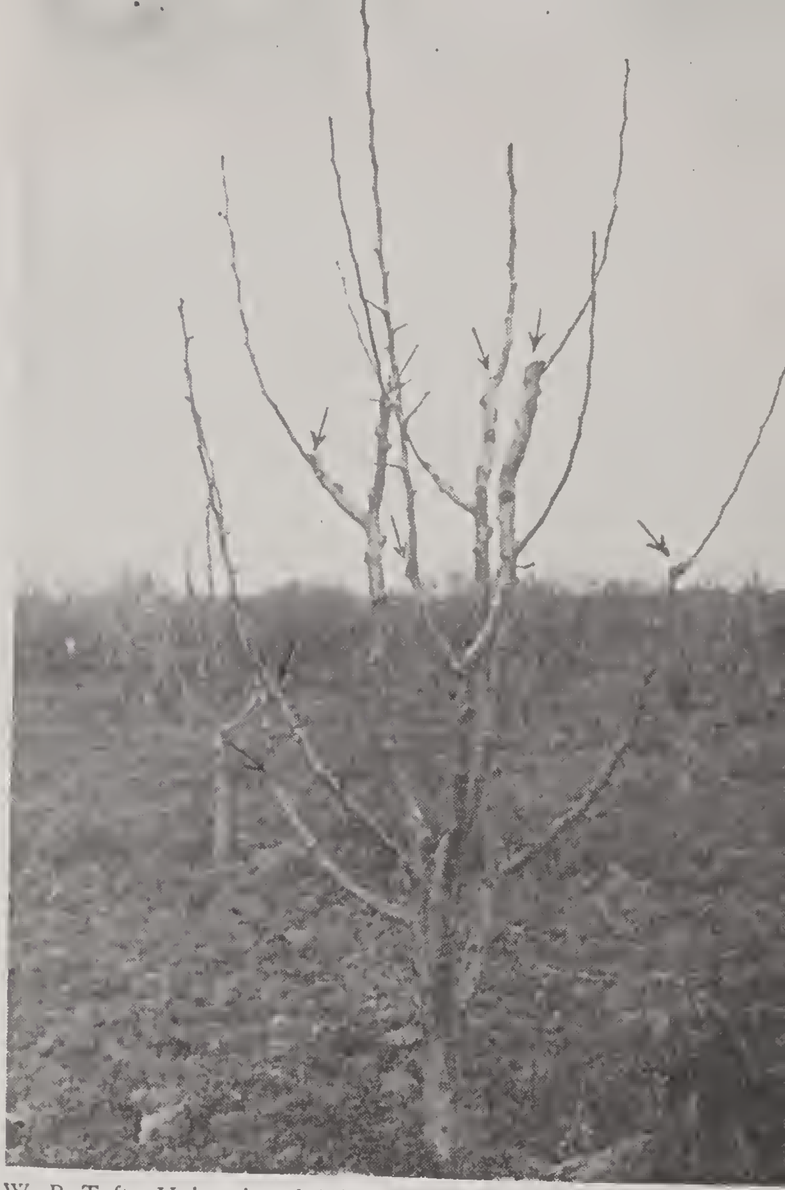
Figure 154. Bartlett pears showing varying degrees of black-end, a physiological disease aggravated by certain rootstocks, including *Pyrus serotina*. Varieties grafted on *Pyrus Communis* have been relatively free from the disease.

Manchurian pear (*P. ussuriensis Maxim*) and Tu Li or Doo Li pear (*P. betulaefolia Bunge*), the latter being alkali resistant, are both susceptible to blight, and pear varieties grafted thereon may produce black-end fruit.

Dwarf or semidwarf pear trees on quince stock (*Cydonia oblonga*) are popular in home plantings in the United States (Figure 155), with some commercial orchards located in California. A considerable percentage of pears grown in Europe are on quince stock. Such trees have the advantages of coming into bearing earlier, economical in management due to lower trees, precocious and regular fruiting, larger and better-shaped fruit, earlier maturity in season, and excellent-quality fruit. The main disadvantages are (1) the tendency of quince roots to sucker badly, (2) their susceptibility to blight, (3) greater cost of propagating double-worked trees, and (4) the need for more trees per acre. The Angers quince (East Malling Type A) is most frequently used. The East Malling Type B and Type D are also used. The Bartlett variety tends to form a weak union with the quince, whereas Anjou, Hardy, Vermont Beauty, Howell, and Clapp Favorite form fairly strong unions. In double-working Bartlett or varieties not congenial with the quince, an intermediate stock of Hardy can be used. In California, the quince and French stocks, in spite of their weaknesses, are recommended above other stocks as the safest investments in commercial orchards.

The Old Home variety of pear as an intermediate stock on French understock is being recommended for both eastern and western orchards. This is because Old Home variety is (1) highly resistant to blight, (2) vigorous, spreading, and upright in growth, (3) can be readily budded or grafted to standard varieties, (4) is satisfactory on either French or quince understocks, and (5) is only occasionally susceptible to canker trouble.

Top-working. If the practice of using the Old Home variety for an intermediate stock on pear trees continues to increase in popularity, then top-working in the orchard may become a standard operation in starting a pear orchard. In this case, Old Home trees are planted with French pear seedling roots and grown in the orchard for three or four years until a good framework is established, as shown in Figure 155. At this time, four to six leaders should have been established, each with possibly an equal number of secondary branches. All of these branches are then either budded or grafted to the desired commercial varieties. Top-working is performed preferably about five feet above the ground. When blight susceptible varieties are used for the top, they should be inserted about ten to twelve inches from the nearest branch of the resistant stock.



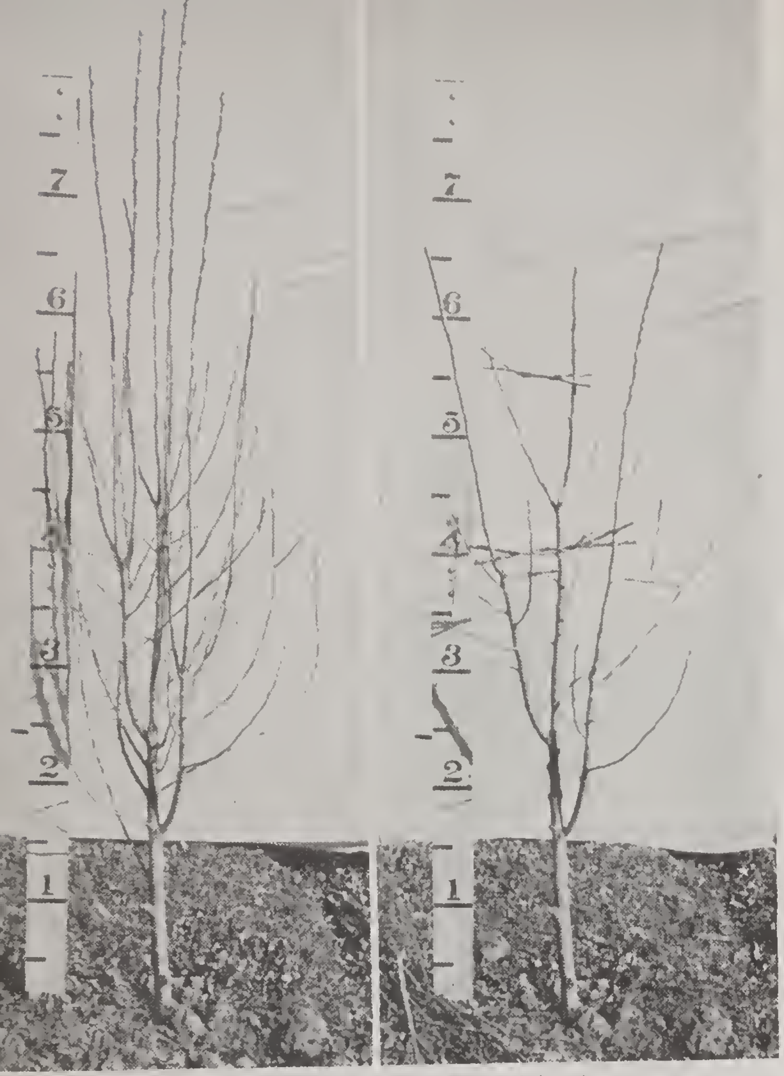
W. P. Tufts, University of California

Figure 155. To avoid fire blight, Old Home pear trees budded on French pear seedling roots are being recommended both in the West and in the East. After three to four years in the orchard, the Old Home trees are top-worked by budding or grafting to a commercial variety such as Bartlett, as shown above. Grafts have been made at points indicated by the arrows.

Old pear trees can be top-worked, using either the bark- or cleft-graft. In the East, the same system for top-working apple trees can be applied to pear trees. In California, the entire top of the old tree is usually removed back to stubs three to six inches in diameter. From two to six cions are inserted in each stub, using the bark-graft method. (See Chapter VIII for grafting and budding technique.)

TRAINING AND PRUNING PEAR TREES

Young trees. The young pear tree is trained and pruned to the modified-leader system as recommended for the apple in Chapter IV. In the West where fire blight is not so likely to be a serious problem, three or four main scaffold limbs may be left (Figure 156). However, where fire blight is a problem, as in the East, it is recommended that about six scaffold limbs be left in the event that subsequent fire blight infection may necessitate the removal of some of the branches. Light pruning is recommended, especially in the East, because blight is more difficult to control on trees making soft growth as a result of heavy pruning.



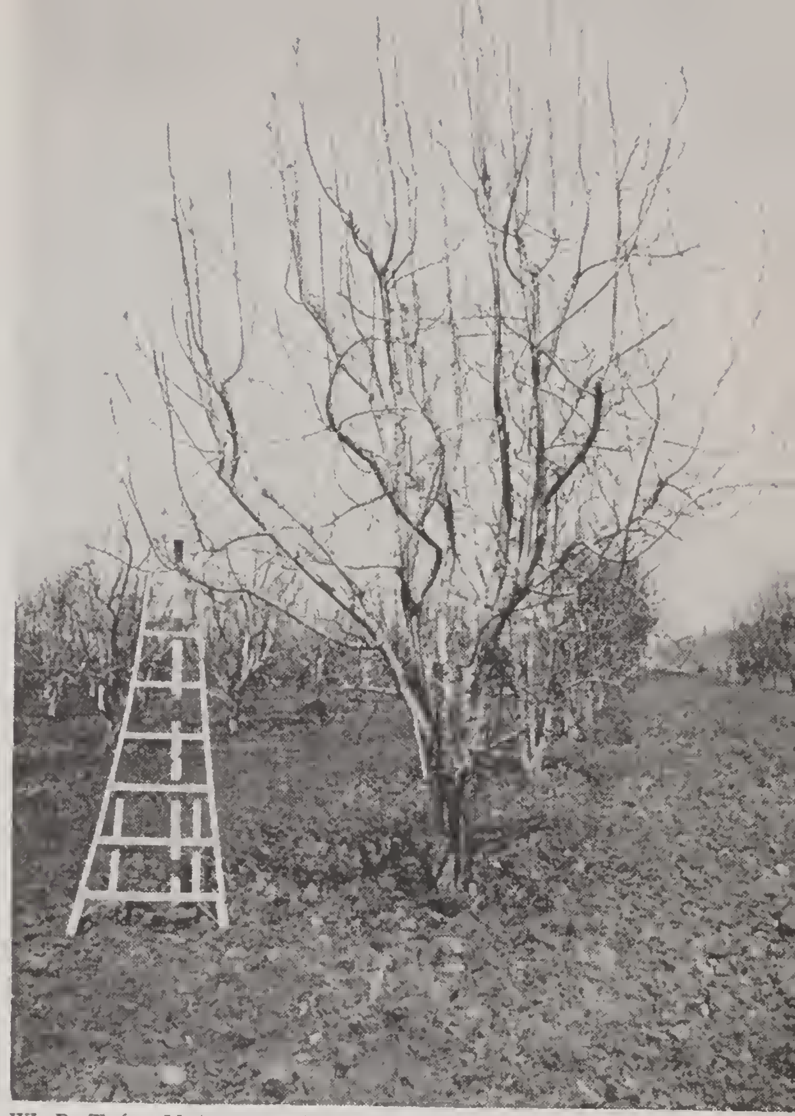
W. P. Tufts, University of California

Figure 156. A young Bartlett pear tree before and after the second dormant season pruning, as recommended in California.

It is characteristic for most pear varieties to grow strictly upright, and not branch freely. Heading-back cuts to outward-growing branches should be kept to a minimum because they encourage a profusion of soft terminal shoots. It is best to confine most of the cuts to the thinning-out type. The upright branches of young pear trees can be artificially spread by placing wooden wedges in the crotches or by tying the limbs down either to the trunk or to stakes driven into the soil. This shifting of polarity tends to induce shoots and spurs along the branch that subsequently become fruitful. Once the tree has begun moderate production, the weight of the fruit will help to give the tree a spreading habit of growth. With young trees, it is important to prevent any one branch from bearing so heavily that it is weighted and trained toward the ground, impairing its future usefulness. With the Anjou variety, the habit of growth is somewhat more spreading and, therefore, mechanical spreading is usually not required.

Caldwell system. This system of training pear trees is used to a limited extent in the West and involves the tying down of upright one-year-old shoots at an angle somewhat below the horizontal. New shoot growth arises below and behind the point of the bend. Growth beyond the bend is practically all reproductive and rapidly develops a good fruit-spur system. Bending of the branches seems to induce fruitfulness. During each dormant season, the new vigorous shoots are tied down so that they shade as little as possible the lower branches. As the tree becomes taller, the upper limbs are tied to any convenient point on either the trunk or a branch below. As the branches begin to fruit, they are naturally trained out and downward by the weight of the fruit. Although this system has the advantage of early relatively heavy bearing, it requires considerable skill and judgment for successful results.

Pruning mature trees. A fruit bud of the pear is similar to that of the apple, containing from five to seven flowers at the terminal of a leafy cluster base. Pear fruits are largely borne on spurs whose economic life is about seven to eight years. A given spur generally fruits from a terminal bud every other year. Some varieties, such as Bartlett, also may bear fruit both laterally and terminally on one-year shoots. This is true up to the age of ten years, after which a progressively greater part is borne on spurs. Fruit buds borne on shoots usually blossom about ten days after the spur buds; thus, if spur buds have been destroyed by spring frosts, fruit buds on the shoots may give rise to the major portion of the crop. Therefore, on these varieties, shoots left for fruit production should not be headed back because the fruit buds usually exist on the outer one-third of the shoot.



W. P. Tufts, University of California

Figure 157. A Bartlett Pear tree after pruning in the Sacramento Valley, California. A few heading-back cuts have been made, but most cuts have been of the thinning-out type.

With mature trees, judicious thinning out of new shoots and of an occasional older branch is to be recommended over heavy heading-back that may result in succulent growth susceptible to fire blight. Thinning-out tends to stimulate spur formation. In a bearing pear tree, new growth of about six to ten inches each year is desirable. The type of pruning on bearing trees may vary considerably from one region to another. For example, the mature Bartlett pear in California is pruned more heavily by heading-back cuts in the Santa Clara Valley in order to maintain sufficient renewal wood and to prevent the production of large crops of small fruits. On the other hand, in the Sacramento Valley where vegetative growth is more vigorous (Figure 157), it is advisable to prune lightly by using mostly thinning-out cuts. Wood of the Bartlett pear in the Santa Clara Valley is distinctly softer and more brittle than in the Sacramento Valley.

When the Bartlett tree is mature and fully occupies its allotted space, there is apparently little effect of any reasonable system of pruning on the size of the crop and time of maturity. Based upon experience in California, this evidently is true regardless of the region. In other words, if adequate replacement wood is obtained without severe pruning, it makes no difference whether these results are obtained by thinning-out, heading-back, or by a combination of the two.

Fire blight treatment. If it is necessary during the growing season to cut blighted branches in order to save important limbs, cut a foot or more below the lowest point where blight is showing and promptly disinfect the shears, saw, and wound with a solution of 1 to 500 bichloride of mercury (poisonous) and 1 to 500 cyanide of mercury (poisonous) mixed together. Place the solution in a bottle, tie a sponge over the opening, and daub the wounds and tools with the wet sponge.

In the East and regions where fire blight is a definite problem, all water sprouts and spurs should be removed regularly from the trunk and lower portions of the main limbs to eliminate this source of infection. Blight can be pruned away with least danger of spreading it when the tree is dormant. It is recommended that this work begin about September 1 when the blighted twigs contrast readily against normal leaves and growth.

SOIL MANAGEMENT

Intercrops. In western states, intercrops of vegetables and small fruits are often grown while the pear orchard is coming into bearing. However, in the East, where there is danger from fire blight, the use of cultivated intercrops is a questionable practice.

Cultivation. In regions where fire blight is not a problem, the cultivation and cover crop system of soil management is commonly employed for pears. This is true in the heavy commercial producing areas of the West. Cultivation starts in the spring by turning under the winter cover crop. Another cultivation may be necessary before the first irrigation. If the soil does not crack badly, the same furrows are used for the second or third irrigation; if the soil cracks, cultivation may be practiced between each irrigation, reconstructing the furrows each time. Frequency of cultivation during the summer period depends largely upon the rate of weed growth.

Cover crops. Voluntary weeds may be used for a winter cover if an even cover can be obtained. Otherwise, a winter cover crop such as yellow sweet clover, common vetch, and purple vetch, may be used. Commonly used nonlegume cover crops are the mustards and cereals such as rye, barley, and oats. Rosen rye is popular in Washington. These are generally planted in the West between the middle of September and the middle of October, or, early enough to give sufficient growth before cold weather. For young trees, a nonleguminous cover crop seems to be preferable. One of the disadvantages of a leguminous cover crop in young or mature orchards is the stimulation of tree growth due to the extra nitrogen, making the trees more susceptible to blight infection. Alfalfa and sweet clover with young pear trees, also, have the disadvantages of encouraging damage to the buds by the tarnish plant bug and damage to new wood by the buffalo tree hopper. Better growth of legume covers can be obtained on some soils in Washington by the addition of 100 pounds per acre of a treble superphosphate applied between December and February.

In the East, it seems advisable to cultivate the young pear trees once or twice early in the season during the first two or three years. Narrow strips are disked on each side of the trees. After the third year, the trees are placed in sod alone or sod plus additional mulch. Subsequent cultivation, if practiced, should be on a very limited scale early in the spring. The grower should be cautious with practices which induce excessive and soft shoot growth.

Commercial fertilizers. Nitrogen is the only commercial fertilizer which has shown general response in pear orchards. Fertilizer applications are not needed if the young trees are making from 12 to 16 inches of new terminal growth and the bearing trees are making from 6 to 12 inches.

In the use of manure or commercial nitrogen, fire blight is the chief consideration. Pear trees must be fertilized with extreme caution. Too much growth may result in loss of an entire orchard in a year or less due to blight.

Manure should not be used on young pear orchards. In Washington, where available, well-rotted manure is recommended on mature orchards when applied in moderate amounts of four to six tons per acre annually in late fall and winter. The manure should be broadcast uniformly over the entire surface of the orchard. The addition of 30 pounds of superphosphate to each ton of manure applied may benefit the growth of leguminous cover crops.

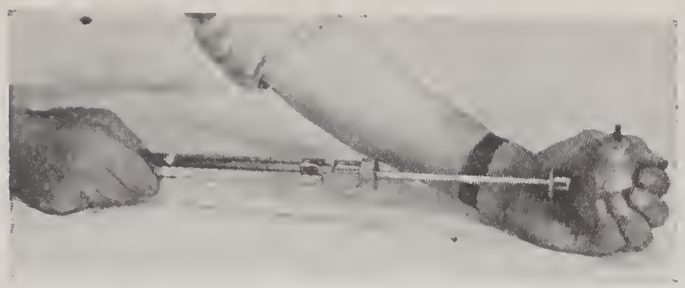
In Washington, some difficulty has been encountered with boron deficiency; applications of 30 pounds per acre of boric acid has corrected corky spot and the characteristic bronzing and rosetting of the leaves. This amount is usually sufficient to protect the trees against boron deficiency for three years. If alfalfa is used for a cover crop, ten pounds of boric acid is recommended because alfalfa will not tolerate larger amounts. Application is made in August or early fall.

Irrigation. Irrigation is a standard practice in the West and is carried out as recommended for apples in Chapter V.

FRUIT THINNING

Relatively little fruit thinning is practiced with pears. In case of such varieties as Bartlett, Hardy, and Bosc which tend to set heavy crops of fruit in clusters of three to five fruits on a single spur, it may be necessary to reduce the number of fruits per cluster to one or two each. If the set on the entire tree is not excessive, however, fruit in these clusters may reach satisfactory size and quality without thinning. With an extremely heavy set of fruit, obviously, thinning is essential to obtain good size and quality. Under these conditions, the work is usually not done until a few weeks before harvest, and the crop is lightened chiefly by removal of the very small and blemished fruit.

In Washington, larger size fruits are required for canning and drying than



D. Ballauf Mfg. Co., Washington, D. C.

Figure 158. Fruit pressure tester is used to determine firmness of pear flesh as an indication of the time for harvest. Slice of skin is removed from the pear, rounded plunger 5/16 inch in diameter is pushed into the flesh to a depth of 5/16 inch. The tester records pressure necessary to force plunger into flesh.

for fresh fruit market. The growers usually secure this size by spot picking the larger fruit first. The remaining pears are permitted to hang on the tree for seven to ten additional days in order to attain adequate size. This increase in size may be 2.5 per cent per day during this period. It is important, however, that Bartlett not be permitted to remain too long on the trees to attain the desired size, or losses from core breakdown will occur in cold storage or at the time of preparation for canning.

From 20 to 30 average-sized leaves per fruit are required for proper sizing of Bartlett and most pear varieties. Thirty or more leaves are required in Washington for cannery size and, in addition, to assure development of fruit buds the following year. With a large leaf area per fruit, pears tend to be relatively high in sugars and dry matter and have a more characteristic flavor than when grown with a small leaf area per fruit.

During heavy crop years in California, bracing of heavily laden branches is frequently practiced. Wooden props are used, or the branches are tied together with ropes. More expensive braces are rarely justified for pear trees. Due to their upright growth habit, they can carry a considerable burden if properly trained when young.

HARVESTING AND HANDLING PEARS

Pears are unlike most deciduous fruits in that they attain highest quality when harvested in a slightly "green" stage. At this stage, they must have developed sufficiently to reach highest quality when ripened off the tree, but not so mature as to impair quality of the ripened fruit. This is principally true for the Bartlett variety. Some varieties such as Anjou and Bosc, however, develop better eating quality by being permitted to become somewhat more mature before harvesting.

Picking maturity. It is rather difficult to select the proper time to pick pears. As the fruit develops and ripens to maturity, the most obvious stages include an increase in size, increases in sugar content, soluble solids, softness, and odorous constituents, and a gradual change in ground color from green to yellowish-green followed by a greenish-yellow, and finally a full yellow. Size cannot be relied upon as an index for picking because fruits of different size may be of the same maturity.

The better criteria for determining maturity of pears are: color change, change in firmness of flesh, and change in soluble solids, all of which indicate a change in sugar content. Color charts are used in California to note progressive ground color changes: No. 1 is green; No. 2, light green; No. 3, yellowish-green; and No. 4, yellow. Softness of flesh is determined by using a pressure tester, as shown in Figure 158. The pressure-test limits for harvesting certain varieties of pears in Washington are given in Table 14. These figures may vary somewhat in other states. The soluble solids are determined by using a refractometer on part of the juice obtained while making the pressure test.

TABLE 14

THE PRESSURE-TEST LIMITS RECOMMENDED FOR HARVESTING WASHINGTON VARIETIES OF PEARS.

(After Overholser et al.)

VARIETY	PRESSURE IN POUNDS			LOCALITY
	Passable	Optimum	Low	
Anjou	15	13	10	Wenatchee
Anjou	15	13	11	Approx. applicable generally
Bartlett	23	20	16	Wenatchee
Bartlett	23	17	15	Yakima (canning only)
Bartlett	23	20	17	Approx. applicable generally
Bosc	16	13	11	Wenatchee
Bosc	15	14	11	Approx. applicable generally
Comice	13	11	9	Wenatchee
Comice	13	11.5	9	Approx. applicable generally
Easter Beurré	..	15	..	Wenatchee
Flemish Beauty	..	13	10	Wenatchee
Winter Nelis	15	14	10	Wenatchee
Winter Nelis	15	14	11	Approx. applicable generally

The ease with which the stem can be separated from the spur by an upward twist is also used as an index of maturity. Number of days between full bloom and maturity for pears is fairly consistent within a region but may vary between regions. In Washington, the following intervals are suggested: Bartlett, 110 to 115 days; Bosc, 130 to 135; and Anjou, 145 to 150 days. Pears on heavily loaded trees usually mature somewhat slower than those on lightly loaded trees.

The maturity at which pears are picked may vary with the purpose for which the fruit is grown. Early shipping pears in California are usually picked as soon as possible in order to take advantage of higher prices on the early pear market. For this purpose, the grower picks his fruit as soon as it meets the maturity standards of his state with respect to pressure or color or soluble solids. If earliness is not a factor, the fruits may be left on the tree somewhat longer in order to increase tonnage per acre.

In picking pears, size of fruit is taken into consideration, in addition to the criteria mentioned above for picking maturity. Size is based on the largest cross diameter of the fruit and is determined by passing the fruit through a given diameter ring which each picker carries. After a little experience, the picker becomes proficient in estimating the size of fruit by the eye, checking occasionally against the ring. On the West Coast, rather definite sizes are requested for given purposes based on the choice of the grower, the buyer or shipper, or upon an agreement between growers and shipper. In general, Bartlett fruits which are less than two and one-quarter inches in diameter are too small for harvest and, therefore, are left on the tree for further sizing.

Pear trees picked for the fresh fruit market are usually spot picked three to five times, harvesting each time all fruits above a specified size. Pears tend to bruise more easily than apples and, therefore, should be handled with extreme care from the time they leave the tree until packed in the box. Abrasion of the skin and discoloration of the flesh can be reduced by lining the field boxes with newspapers.

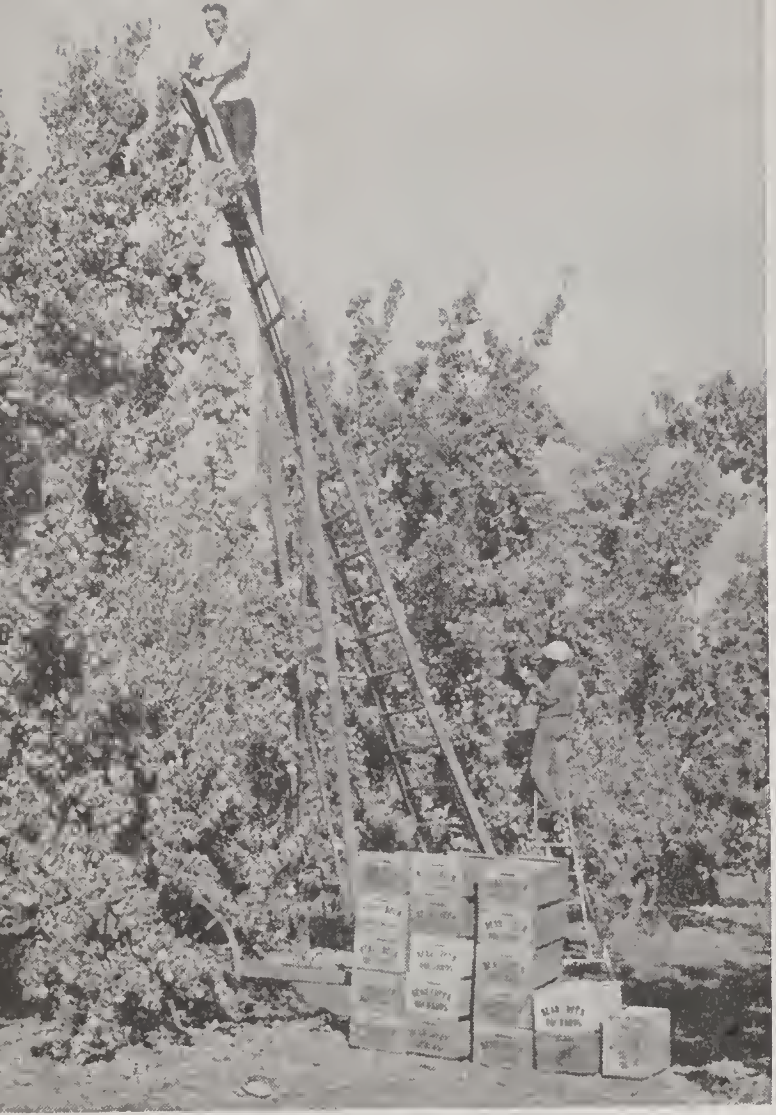
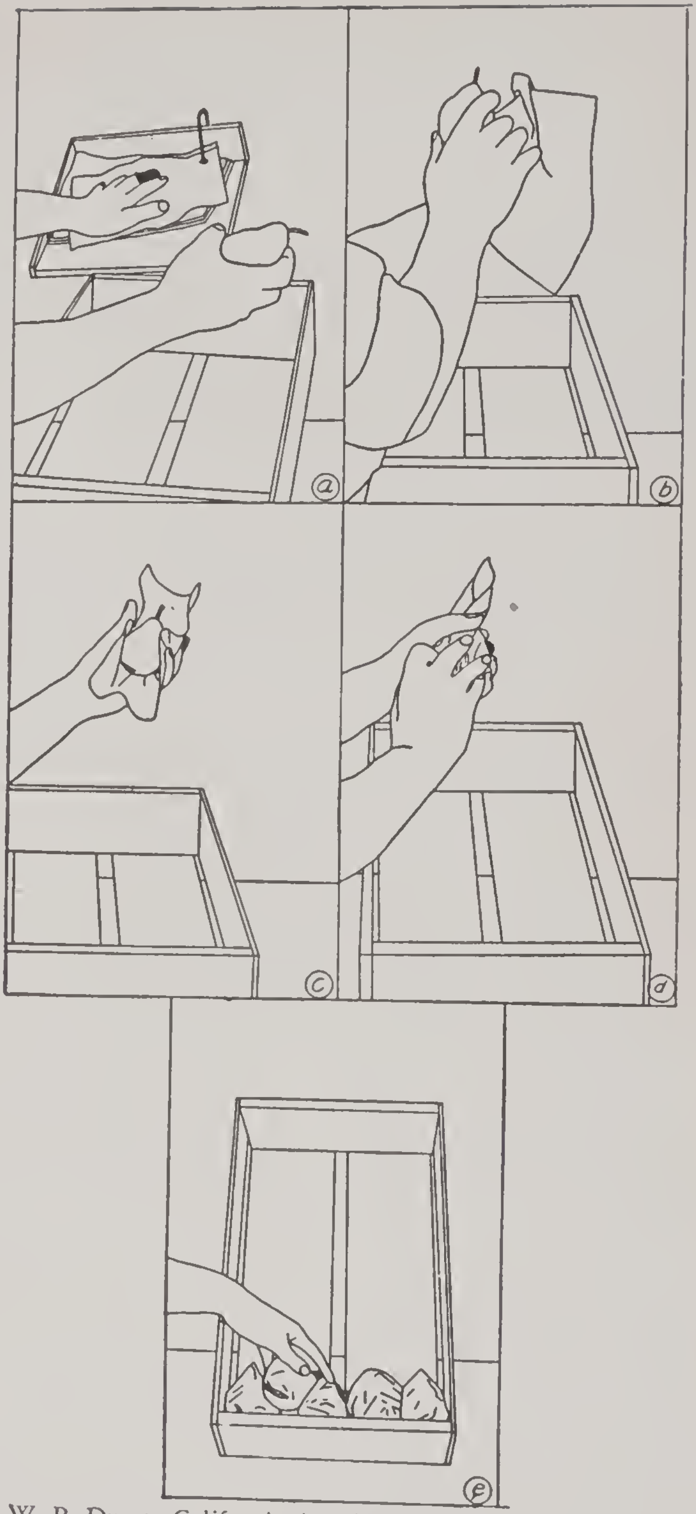


Photo by Shangle, courtesy C. D. Cordy, Medford, Oreg.

Figure 159. A pear harvesting scene at Bear Creek Orchards, Medford, Oregon. Note type of picking ladder employed for relatively high and upright-growing pear trees.

Hormone sprays to reduce pear drop. In California, the use of hormone sprays by pear growers has become a standard practice. Washington and Oregon, likewise, are using preharvest sprays to reduce drop. The concentration used is about ten parts per million of alpha-naphthaleneacetic acid or naphthaleneacetamide. The manufacturer's recommendations should be followed as to quantity of material and the use of a spreader or oil. Either powder or liquid forms appear to be equally effective. The spray is applied about five to seven days before harvest or when there is first evidence of drop of normal fruit. In some seasons, it may be possible to incorporate a hormone spray with the last codling moth spray applied to Bartlett pears.

These hormone sprays do not slow down the ripening process; in fact, there is evidence to indicate that ripening may be accelerated somewhat whether the fruit is on or off the tree. Pear fruits must be harvested *at the proper maturity* with little or no delay, stored as soon as possible, and the temperature of the fruit reduced quickly to 35° F. or lower within 48 hours if at all possible. On trees sprayed with preharvest sprays, there may be a number of overripe fruits which did not drop, making it necessary for the overripe fruit to be sorted out either by the picker or by the packing crew. It cannot be overemphasized that every effort should be made to harvest pears at the proper stage of maturity regardless of whether they have or have not been sprayed with hormone sprays. It should be borne in mind that if the grower permits hormone-sprayed Bartlett pears, for example, to remain on the trees ten days after proper maturity, the fruit may show core breakdown during subsequent ripening and storage previous to canning.

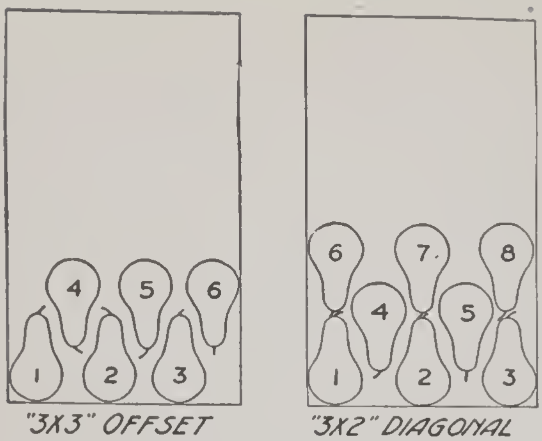


W. P. Duruz, California Agr. Exp. Sta.

Figure 160. Progressive steps for wrapping and packing pears in boxes. See pages 266 and 267 for description of steps.

Spray residue removal. In many regions of the West, there is a decided buildup in spray residue on the fruit due to low rainfall during the growing season or to the use of oils, or both. The present tolerances for pears are the same as for apples, as discussed in Chapter X. Pears to be used for canning need not be washed, inasmuch as the skin, stem, and calyx are removed during the canning process. The methods and solutions used for washing pears are similar to those recommended for apples, except that the use of alkaline washing materials is not generally recommended, especially for russet pears, because of the difficulty of rinsing and of the danger of injury to the fruit.

Waxing of pears. Waxing of pears to reduce shriveling and ripening and to increase luster has been performed successfully on an experimental basis, using either a 4 per cent emulsion of paraffin wax or a 4 per cent emulsion of wax made up with a ratio of two parts of carnauba wax to one of paraffin wax. Waxing appears to be most promising for varieties which have been



W. P. Duruz, California Agr. Exp. Sta.

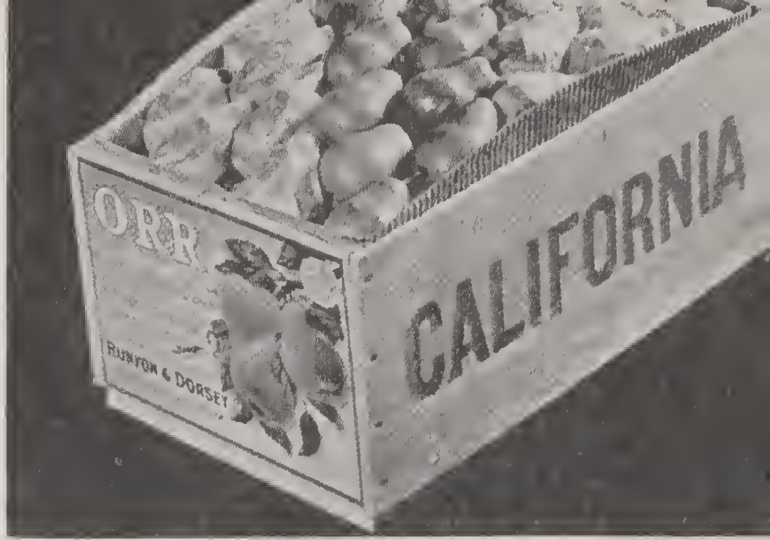
Figure 161. Two styles of pear packs commonly used. Stems in first row next to packer should point away from packer; stems of fruit in other rows point toward packer.

washed with an alkaline solution and have lost some of their natural wax and luster. Further experimental studies are needed to perfect pear waxing.

Grading and sizing. In the packing house, the pears are first run through a bath to remove spray residue and then rinsed in clear water and dried in an air blast before delivery to the sorting table. At the sorting table, the culls are eliminated, and the low-grade fruits are separated from the high-grade fruits. Each grade is sized into several sizes. The rotary-bin-type of sizing machine, as described for apples in Chapter X, is also well adapted to pears. The machine must handle the pears with extreme care. Pears packed in boxes must be of uniform size with a variation of not more than one-half inch in diameter for pears two and three-quarter inches in diameter or larger. For pears smaller than two and three-quarter inches in diameter a variation of not more than three-eighths inch is usually permitted in California.

Containers. The standard box for pears has the same inside width and length as the peach and apple boxes (11½ by 18 inches), but it is only 8½ inches deep. These dimensions are generally accepted in all producing sections, except the states of New Mexico and Washington, which designate an 8-inch-depth as standard. The half-box is standard in Oregon; it is 4½ inches deep with the above length and width dimensions (this is the same size as the 4½-inch-depth peach box). There is a special 5½-inch-depth box for pears used for export shipments from California. This same box and one that is 9½ inches deep are standard in Oregon for a three-cushion pack of pears. The 4¼-, 4½-, and 4¾-inch fruit boxes are standard for pears in California, as also are the grape lug and a special lug 6½ by 13½ by 20⅝ inches in size. In New York, which ships more pears than any other eastern state, the ½ and 1 bushel tub baskets, as well as the barrel, are used. Illinois and Michigan use both the tub and round-bottom bushel baskets, but the latter is losing popularity rapidly.

Pear packing. Each packer handles only one size of pear from the rotary bins. The pear is picked up with the right hand (Figure 160), while the left is grabbing a sheet of wrapping paper. The pear is thrown into the left hand, stem up, with some force so that it rests between the thumb and forefingers. Corners of the paper are then folded over the calyx end of the pear, and the pear is turned up with the right hand while the left hand and fingers twist the paper around the stem of the fruit to form a point. The pear is then placed in the box with the left hand, as shown in Figure 160. The first row of fruit next to the packer is laid with the stems away from the



California Fruit Exchange, through L. D. Davis, University of California

Figure 162. Properly packed standard pear box. Note one and one-half to three-inch bulge at top center to allow for shrinkage and to prevent shifting and bruising of pears in transit.

packer, but for other rows the stems are all placed toward the packer. The right hand reaches for another fruit while the left hand is placing a wrapped pear in the box. The process of wrapping fruit by hand is claimed to be faster than if the fruits are not wrapped. Also, wrapped pears stay in place better than unwrapped pears, because, in addition, they are provided with a cushion of paper which helps to restrict the spreading of rots among the pears.

The two commonly used styles of packing pears are the "offset" and the "diagonal." The "offset" or "3 × 3" pack is employed for sizes of pears that will give five or more fruits across the box, as shown in Figure 161. The "diagonal" pack, or "3 × 2," is used for larger pears.

The pears should be arranged in the box so there is a 1½- to 3-inch graduated bulge at the topcenter of the box. This is done by placing somewhat larger pears in the center of each layer and, also, by pointing the stems in this region at a slightly steeper angle upward than in case of the pears toward the ends. A well-packed pear box is shown in Figure 162. The more or less high bulge is needed for pears because they tend to show relatively more shrinking in transit. If pears are packed looser than recommended, they may soon become disarranged and shake around in the box, resulting in considerable bruising and rapid decay.

Packed boxes are marked with the total number of pears contained, the grade and the shipper's name and address. The standard pear boxes may contain the following number of fruits, depending upon their size: 70, 80, 90, 100, 110, 120, 135, 150, 165, 180, 195, 210, 228, and 245.

Precooling. The practice of precooling is becoming popular for the shipment of pears from the West to the East Coast. Methods for precooling are described in Chapter XIV. Precooling has the advantage of not only quickly reducing the rate of ripening, but also reducing or eliminating entirely the need of re-icing in transit.

STORAGE OF PEARS

Due to the fact that respiration and the breaking-down processes in the pear are more rapid than the apple, it is highly important that the temperature of pears after picking be reduced as quickly as possible, using the most effective means of refrigeration. If there is a delay between harvest and storage, allowing the ripening processes to become accelerated, it becomes difficult to retain pears satisfactorily in storage. A storage temperature of 30° to 31° F. is recommended for the longest storage life of pears. A temperature of 36° F. reduces the storage life to about one-third to one-half in the shorter-lived varieties, such as Bartlett, Comice and Hardy. Pears at either temperature, however, tend to show more loss than apples under comparable conditions.

Although pears may be undercooled in storage, their critical freezing temperature is about 27.7° F. This is only about two degrees below the minimum storage temperature recommended for retaining pears in best fresh condition. Anjou pears frozen for a week at 23° to 27° F. usually recover with little or no injury to the flesh, but if frozen for four to six weeks at these temperatures, the fruit becomes waterlogged under the skin and sometimes in the core region.

Ripening of pears in storage. With the fall and winter varieties, such as Hardy, Anjou, Comice, Bosc, Winter Nelis, Glou Morceau, and Easter Beurré, the highest quality is attained by storing and ripening under carefully controlled conditions of temperature and humidity. Because of the need of these rather definite conditions, an increasingly common practice is to store the fall and winter varieties in rooms at 30° to 31° F., removing them as the trade requires and ripening them in special rooms at temperatures between 60° and 70° F. with the humidity well controlled between 80 and 85 per cent, before delivering to the retailer. This process insures maximum quality to the consumer. If pears are ripened above 70° F., they may not soften properly and remain slightly firm until decay or breakdown sets in. Also, they may be tough-textured and poorly flavored. These special ripening rooms have been established in the eastern terminal markets by the West Coast shippers.

It is important to have a knowledge of the limitations of each variety with respect to its storage life. For example, the Bosc is at its best from September 1 to December 15 in California and should never be held beyond the Christmas holidays. It must be held constantly at 30° to 31° F. and ripened at 60° to 70° F. The Bosc will not ripen in cold storage and will lose its ability to ripen if held for any length of time at temperatures between 34° and 35° F.

In Washington, Bosc and Clairgeau when stored at 30° to 31° F. can be utilized best from September 1 to January 15; Anjou, Conference, and Forelle, from October 1 to April 15; Comice from October 1 to February 1; and Winter Nelis and Easter Beurré are not ready until December 1 and may be kept until May.

The Bartlett variety tends to have better color and texture for canning if stored immediately after picking for 15 to 30 days before being processed. Bartlett pears harvested at pressure tests of 17 to 15 pounds give a fairly good product when stored at 30° to 32° F. for as much as 60 days before canning. If they are retained in storage unduly long, however, core breakdown, rot, scald, softening, and browning of the tissues may result. This is particularly true if the pears are overmature when harvested, or if they are held at room temperature for three to six days after picking before they are stored.

The Kieffer pear has been shown to develop surprisingly good quality when harvested at 14 to 13 pounds pressure and stored for 90 days at 32° F., and then ripened at 60° F. Kieffer pears allowed to remain on the trees until overripe develop excessive grit cells, are apt to become dry and mealy, and soften too rapidly around the core. Pears removed from the tree can be ripened immediately at 60° to 65° F. in order to obtain full flavor and juiciness with splendid texture.

Although the pressure tester can be used effectively for determining harvest maturity of pears, it is not satisfactory for measuring the ripeness of pears during cold storage.

Ripening pears with ethylene. Ethylene gas hastens pear ripening, except for the Kieffer variety which does not seem to be affected either by artificial treatment or by the natural emanation of ethylene gas from nearby ripening pears. The use of ethylene gas may be desirable and profitable in hastening the ripening of Bartlett pears for canning, which appear to be ripening unevenly. This has been demonstrated by placing containers of pears in a closed chamber and exposing them intermittently to concentrations of ethylene of from 1:1000 to 1:5000. At the end of each 24 hours, the ripening rooms are aerated for one hour, using a fan to exhaust the products of respiration. Treatments on four successive days are usually adequate. Where ripening of the fruit is uniform without ethylene treatment, use of this gas has no advantage. The effects of ethylene upon the ripening of pears are apparent only if the gas is used a short time after harvest. If the pears have been in cold storage for several weeks, they show little or no response to ethylene gas. Effects of ethylene are most pronounced at temperatures of 65° to 70° with little or no effect at cold storage temperatures.

Modified atmosphere storage. As in the case of apples, pears can be kept in storage for several weeks longer by manipulating the temperature and the oxygen and carbon dioxide concentrations in the storage air.

Each variety appears to ripen best at specified gas concentrations and temperatures. For example, Bartlett and Hardy have stored well at 5 to 10 per cent carbon dioxide and 2.5 to 10 per cent oxygen at 45° F. On the other hand, Conference pears keep well at 2.5 per cent oxygen and 5 per cent carbon dioxide at 34° F. Specific gas concentrations and temperatures have been determined for several varieties.

Canning pears. Pears which are picked for canning usually have a lower pressure test than pears used for fresh fruit. They are permitted to attain a larger size on the tree and less pickings are necessary.

The canning factories specify the grade, range of sizes, and ratio of length to diameter of fruit which they will accept from the producer. The ratio of length to diameter desired will vary from one district to another; a greater ratio is demanded for pears from Washington than for pears from California. Fruit is bought by the ton. A premium price is paid for fruit from certain production areas which the canners believe will produce a superior canned product.

As stated previously, pears are placed in large ripening rooms of controlled temperatures and humidities upon arrival at the cannery. The fruit is sorted frequently in these rooms in order to process the individual fruits as they reach the proper stage of ripeness. If the cannery is overloaded when the fruit arrives, the pears are placed in cold storage at 30° to 32° F. and later removed to the ripening rooms at 60° to 70° F.

Drying pears. Only about 3½ per cent of the total pears produced are dried, but the drying industry offers a good outlet for the overripe pears found among those which are designated for fresh shipment to the East. There is also a certain amount of fruit grown especially for drying, in which case the pears are allowed to remain on the tree longer than usual in order to attain maximum size.

The spray residue must be removed from the pears before drying. The pears are cut in half, the calyx end removed, and the stems cut or pulled out. The core is usually not removed. The halves are spread on drying trays with cut surfaces up. The pears are then sulfured for 6 to 72 hours in order to induce the proper translucency. Common practice in California is to sulfur the pears about 24 to 72 hours. For best color, pears should be exposed to sunlight for one-half to two days, after which the trays are stagger-stacked. The drying process can be completed within two to four weeks.

QUINCE CULTURE

The quince has never attained more than minor importance among fruits. It is grown widely in the United States mostly in home gardens, though in a few states an occasional small commercial orchard can be found. Although the selling price of the fruit may occasionally be high, it does not necessarily follow that quince culture is correspondingly profitable. It is difficult to obtain good yields of high quality fruit because of the prevalence of diseases and insects, the controls for which are difficult for this fruit.[1] Also, the uses of the quince fruit are limited mostly to the making of jelly, marmalades, preserves, or for adding flavor to apples and pears when stewed or baked. Demands for the quince are strictly limited and, therefore, overstocking of the market could be easily accomplished.

The quince is a low-spreading type tree which attains a height usually less than 15 feet. The quince differs from other deciduous fruit trees by developing fruit buds terminally on current-season shoot growth; thus, the fruit buds are not formed the preceding year. Most varieties begin to bear in three to four years and reach a maximum production at ten years, yielding about one bushel of fruit per tree.

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[1] With the advent of DDT, however, good control of the oriental fruit moth, a major insect, is being reported which may make quince growing more attractive.

Soils. Although the quince will grow on a wide range of soil types, a well-drained clay loam, fairly fertile, and moderately retentive of moisture, is preferred.

Varieties. The Orange variety is most popular, followed by Champion, Pineapple, Angers, Van Deman, Rea, and Meech.

Propagation. The desired quince varieties are budded on Angers quince as an understock. The Angers stocks are propagated by mound layering or by cuttings. Most varieties may also be multiplied by cuttings, but some do not root readily.

Trees and planting. Two- and three-year nursery trees are planted about 15 feet apart on the square, making 190 trees per acre. The trees can be trained by the open-center system as recommended for the peach, or the small tree can be cut off 10 to 12 inches above the ground and induced to form a bushlike tree.

Culture. The quince is highly susceptible to the fire blight disease and, therefore, every effort must be made to prevent excessive growth by too much nitrogen or cultivation. Probably the best management is to place the trees in sod after they have been strip-cultivated the first two or three years. Nitrogen should be applied very cautiously. Limited cultivation might be practiced in early spring if the trees are becoming obviously low in vigor.

Pruning. Because of the habit of growth, comparatively little pruning is needed. Quince makes rather slow, crooked, angular growth. Dead branches and limbs which cross, crowd, or interfere should be removed. Pruning should largely consist of thinning-out cuts with occasional cutting-back of main limbs to stimulate moderate shoot growth upon which the fruits are borne.

Review Questions

1. Where are the commercial pear producing regions in the United States?
2. What has been the general trend of tree population and pear production since 1920?
3. List 5 important pear varieties grown commercially along the Pacific Coast; list 2 important commercial varieties grown in the East.
4. Describe a planting plan for a pear orchard in your locality with Bartlett as the main variety. Adequate provision should be made for cross-pollination.
5. Compare the pear with the apple in climatic and soil requirements.
6. According to present information, what appears to be the most desirable and widely used rootstock for pear trees?
7. What system of double-working can be used as a preventive measure against fire blight?
8. Describe the methods for training and pruning a young pear tree before it comes into bearing.
9. Briefly describe the Caldwell system of training and pruning pear trees.
10. How does the pruning system for a mature pear tree differ from that of a mature apple tree?

11. What system of soil management would you recommend for newly planted pear trees and for a mature orchard in your region.
12. When would you recommend commercial fertilizers or manure for a mature pear orchard?
13. Compare fruit thinning of the pear with the apple.
14. What criteria are used for determining the best stage of maturity for picking pears?
15. Briefly discuss the use of hormone sprays for reducing pear drop at harvest time.
16. What temperatures appear to be the best for storing and ripening Bartlett pears?
17. What picking, storing, and ripening procedure has proven best for developing highest eating quality in Kieffer pears?
18. Why has the quince never attained more than minor importance among fruits?

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CHAPTER XIV

Peach, Nectarine, Apricot, and Almond

PEACH CULTURE

The peach comes from Eastern Asia where it was cultivated for centuries before the beginning of the Christian era. It was first brought to the United States by Spaniards, probably on the second or third visit of Columbus. Finding a congenial home, it was widely planted with many trees escaping cultivation and growing in the wild. Pits are still gathered from the descendants of these trees in the regions of South Carolina and Tennessee for use as seedling rootstocks for standard peach varieties.

As shown in Figure 163, peach production in the United States has been on a gradual upgrade since 1920; the largest peach crop on record of over 86 million bushels was recorded in 1946. This crop, however, was substantially above the previous ten-year average of 62,936,000 bushels (1936-45). Total number of bearing trees in the United States in 1940 was 47,147,000.[1] Thus, the average yield for the United States as a whole is a little over one bushel per tree per year.

East of the Rockies, peach production has had many setbacks, largely as a result of planting on sites frequently susceptible to spring frosts and winter freezes. Drought, diseases, and insects also have taken their tolls and caused shifts in the industry from one section to another. In spite of these setbacks, however, peaches rank second to the apple among deciduous fruits from the standpoint of production and value. The upward trends in production in recent years are probably due to (1) better selection of sites and soils, (2) the introduction of somewhat hardier and better quality peaches, (3) increased marketing of the crop at the orchard or roadside stand, and (4) the use of trucks and refrigerator cars to haul the perishable fruit quickly to adjacent or distant markets.

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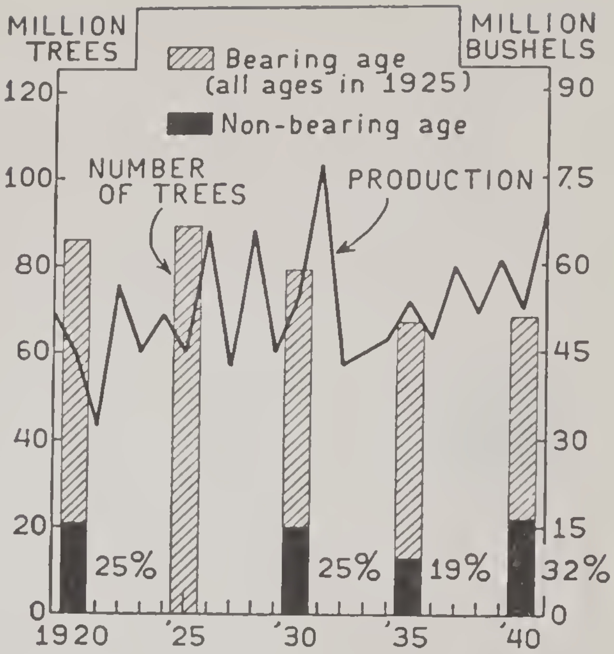
[1] The Federal Farm Census for 1945 showed a total of 66,470,131 peach trees, over 18 million of which were in the South Atlantic states.

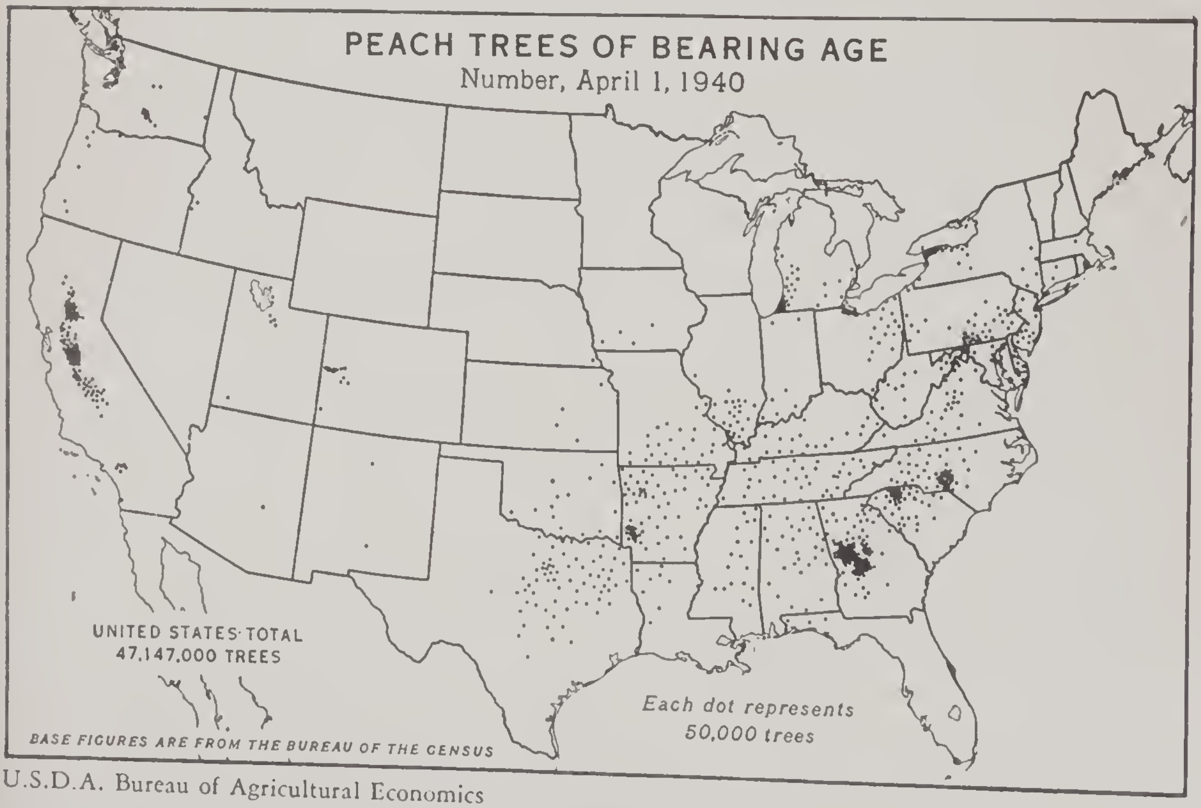
While the peach can be grown in most apple sections, it extends further south than the apple. At a given altitude, peaches will grow and fruit at latitudes much closer to the equator than apples because they are more tolerant of heat, and require less cold to break their rest period.

The distribution of peach trees of bearing age in the United States is shown in Figure 164. It will be noted that the larger peach tree plantings in the northcentral and northeastern states are located near large bodies of water, such as the Great Lakes where the tempering effect of the water is an important factor governing tree distribution in these states. In recent years there have been heavy plantings of peach trees in the Southeastern states, especially in North and South Carolina. Rather large acreage increases have



T. E. LaMont and H. F. DeGraff, Cornell University

Figure 163. From 1935 to 1940, there was a decrease in the number of bearing peach trees in the United States but a striking increase in the number of trees of nonbearing age. Production has been gradually increasing since 1920; in 1946 it exceeded 86 million bushels.



U.S.D.A. Bureau of Agricultural Economics

Figure 164. Distribution of over 47 million bearing peach trees in the United States in 1940. Peaches extend further south than apples because they are more tolerant of heat and require less winter cold to break their rest period.

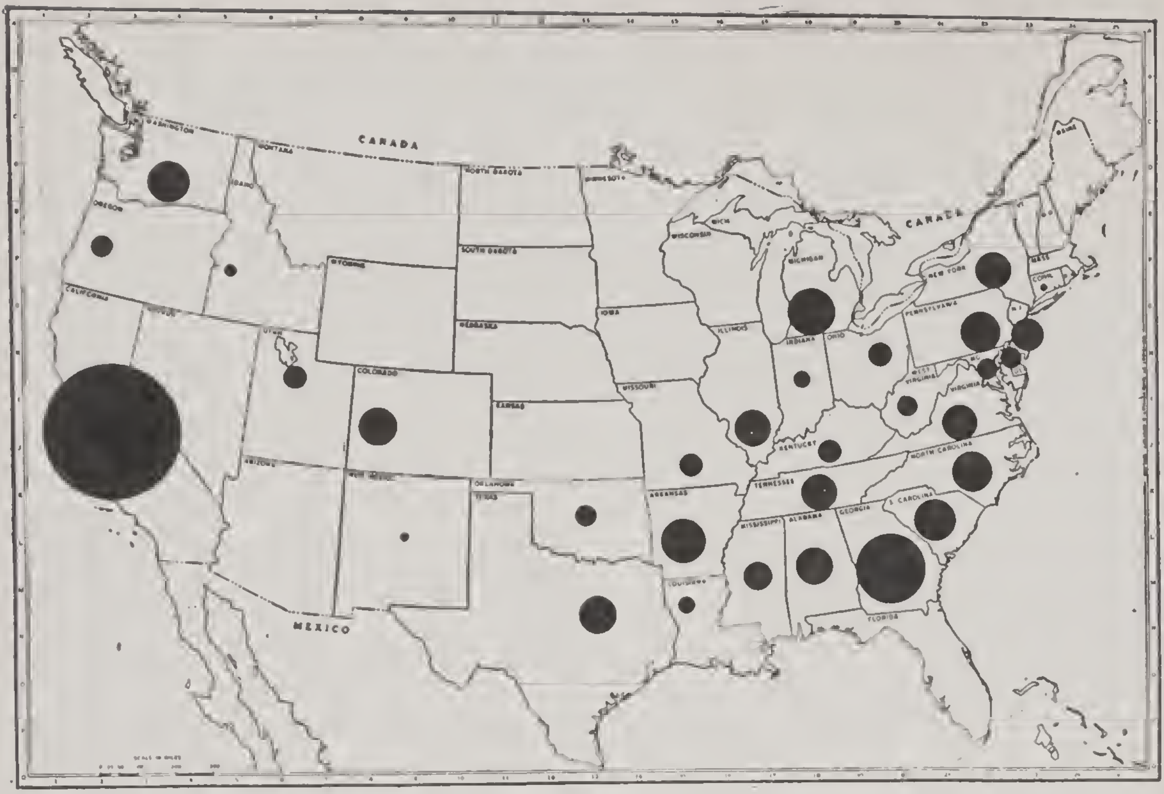


Figure 165. The relative production of peaches by states based on the 1938 to 1947 average. California is by far the leading state, producing 40 to 60 per cent of the total crop. Georgia ranks second.

been made in other districts, notably in Michigan, Pennsylvania, and Washington, while most other states have either held fairly steady or shown slight to moderate increases in plantings. The cold dry winters discourage peach production northwest of a line drawn from Chicago to Amarillo, Texas.

Peach orchards were planted rather heavily during and immediately after World War II because the first good crop of peaches can be obtained within 4 to 5 years after planting, which is sooner than for most deciduous tree fruits. Thus, the grower in many cases was able to benefit from the relatively higher market prices and demand.

Figure 165 shows the relative production of peaches by state based upon the ten-year average from 1938-47, inclusive. California is by far the leading state and accounts for 40 to 60 per cent of the total production, depending upon fluctuation of the crop in the East. California peach production shows little variation from year to year, but production of states east of the Rockies may vary considerably with weather conditions. Production figures for leading states, 1937-46 average, are: California, 27,373,000; Georgia, 5,037,000; Michigan, 3,319,000; South Carolina, 3,151,000; Arkansas, 2,190,000; Washington, 2,081,000; North Carolina, 2,131,000; and Pennsylvania, 1,960,000.

Peaches grown in California are largely processed; about 15 million bushels are canned, five million dried, about one and a half million frozen, and less than five million are sold as fresh fruit. In the eastern states, the majority of the crop is sold fresh, although fair quantities are canned in some states, particularly in Michigan (655,000 bushels for 1945). In 1945, Washington canned 415,000 bushels.

The variety list for peaches is probably changing more rapidly than for any other tree fruit. This rapid change is due to several factors: (1) The tree is relatively short-lived; (2) There is an urgent demand for varietal improvement in hardiness and quality; (3) More good seedlings are obtained from peach crosses than with apples, pears, and most tree fruits; and (4) It takes relatively less time to develop a new peach variety.

Of all the commercial varieties of peaches recommended in Michigan over 25 years ago, only Elberta remains on the list. The same is true for most states. That Elberta leads all other varieties for the country as a whole was demonstrated by the *American Fruit Grower* magazine in a survey of 105 United States nurserymen in 1939; Elberta trees were selling three to one to the nearest competitor in the yellow-flesh freestone midseason group. This indicates that Elberta will probably hold the lead for several years.

Although Elberta is the most important commercial variety in the fresh fruit market, it lacks several desirable characteristics. It does not have the high quality and the desired blossom-bud resistance to low winter temperatures. Also, it ripens relatively late in the season in northern regions and tends to be more susceptible to ravages of the Oriental fruit moth in these areas. The use of DDT, however, shows promise of minimizing this problem. Elberta holds the leading place because it is a large, well colored, firm, excellent-shipping peach, and the tree is vigorous and adapted to a wide range of soil and climatic conditions. In the East, the chief aim in peach breeding is to secure a variety more hardy in bud than Elberta, one which has higher quality, and which ripens earlier.

Choice of peach varieties for any one region is governed by three factors: (1) the type of market to be served, (2) distance to the market, and (3) adaptability to local soil and climatic conditions. If the orchard is located in regions of the country where the temperatures frequently fall to —12° F. or lower, hardy varieties such as Halehaven, South Haven, or Rochester are desirable. For a particular site in the East, it is considered good policy by growers to set the more tender varieties on the high elevations and to locate the hardier varieties on the slopes and lower elevations. Due to the tenderness of Elberta buds, this variety should be planted nearer the top of the slope.

If a large portion of the fruit will be sold at a roadside market, it is desirable to select a number of varieties which will ripen over a period of several weeks in order to give a continuous supply of fruit on the market counter. On the other hand, if the fruit will be sold in large quantities to a co-operative fruit packing association, fewer varieties are needed and only those which are suitable for processing, or which have a wide reputation in the fresh fruit markets should be grown in quantity. In the East, if the peach orchard is located a considerable distance from large fresh fruit markets, no doubt much of the crop will be sold locally, but in case it should be necessary to ship surplus quantities in the fresh state, a portion of the varieties should consist of Elberta or some well-known commercial variety adapted to long shipment.

If the variety is to be used for canning, as is particularly true in California and certain other states, the fruit should be (1) of yellow flesh, (2) preferably a clingstone (although many freestones are canned), (3) firm, (4) of good symmetrical size, (5) no red color at the pit, and (6) a small pit. In California, the varieties preferred for canning have been Tuscan and Phillips Cling, but these are losing favor. More suitable varieties are continuously replacing older ones. Varieties frequently recommended in recent years are from earliest to latest, Walton, Hauss, Johnson Paloro, Peak, Libbee, Gaume, Sims, and Halford No. 2.

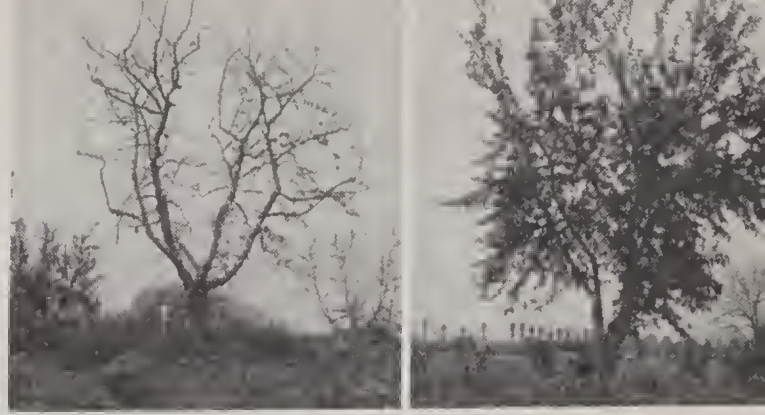
If the fruit is to be dried, it should be a freestone and particularly sweet in addition to the characters given above for canning. For drying, Lovell, Muir, and Elberta lead in California. Muir is preferred over Elberta because it requires about five pounds of fresh fruit to make about one pound of dried; the more juicy Elberta requires seven pounds of fresh fruit to make one pound of dried.

The fresh fruit market prefers a yellow-flesh freestone peach, relatively free from fuzz. It should be fairly early for the region in question, firm, of good size, bright color, and if possible, a good shipper. In addition, it has distinct advantages if it can be canned or dried. Elberta and J. H. Hale ordinarily meet these requirements, but the J. H. Hale has lost considerable favor due chiefly to its shy bearing habit. The Halehaven variety, which was developed by the Michigan Experiment Station from a cross between J. H. Hale and South Haven ranks second to Elberta in the East as an all-round peach. It is little known in California. Golden Jubilee has been popular in the East because of its earliness and resemblance to Elberta but it is losing favor due to its soft texture and poor shipping quality. Jerseyland is a promising early peach in New Jersey.

Table 15, prepared by the Ohio Agricultural Experiment Station, gives a local example of a critical evaluation of many peach varieties receiving attention in the East for the fresh market trade.

In the southeastern states, Elberta leads with Hiley, a white-fleshed peach, ranking second. Early Rose and Belle of Georgia (white flesh) are losing favor rapidly. The U. S. Department of Agriculture has recently introduced the earlier white-fleshed freestones, Dixired and Dixigem, to replace the Uneeda and Early Rose. Also, the Southland, a yellow freestone ripening with Hiley, was recently introduced. Halehaven and Triogen are being planted, but Golden Jubilee is losing favor. In Florida and other southernmost states, varieties of the Peento and the South China races are grown because they are adapted to the warmer climatic conditions, but these varieties are hardly factors in a commercial sense. In southern California in the citrus belt, a peach variety is desired which requires relatively little winter chilling to induce the buds to open in spring. The California Agricultural Experiment Station (Figure 166) has developed several varieties which are superior to Elberta in this respect; namely, Babcock, Ramona, Bonita, Rosy, and others.

Aside from Elberta and a few others such as Halehaven, most peach varieties are regional in their adaptation, performing well in one region or locality and poorly in another. Also, peach variety lists are changing continuously and, for these reasons, it is wise for the grower to keep in touch with his local experiment station regarding the latest and best varieties for the purpose desired.



J. W. Lesley, California Agr. Exp. Sta.

Figure 166. Peach varieties differ considerably in winter chilling requirements. A certoin duration of winter chilling ot a temperature below 45 degrees F. is usually required to induce opening of buds in the spring. (Left) The Elberta tree shows symptoms of insufficient winter chilling during an unusuolly mild winter in citrus belt of California, 1939-1940. (Right) The Ramona variety near by bore o good crop, indicating a lower winter-chilling requirement. Photos taken April 24, 1940.

POLLINATION REQUIREMENTS

Practically all commercial peach varieties are self-fertile. Only a few varieties are self-sterile, including J. H. Hale, June Elberta (Mikado), Hal-Berta, Candoka, Welcome, and Giant. None but J. H. Hale has received wide planting, and it is giving way to better varieties. If a self-sterile variety is used, it should be planted in double rows, alternating with two rows of a self-fertile variety. Bees in the orchard at blossoming provide greater assurance of cross-pollination during adverse weather.

ROOTSTOCKS FOR PEACH TREES

Probably 96 to 98 per cent of the peach trees in the United States are budded on peach seedling roots. Seeds for these stocks in the East were collected mostly from wild peach trees in the Carolinas and Tennessee, but these are increasingly difficult to obtain; nurserymen are using pits of commercial varieties such as Elberta and Lovell. In California pits are selected from waste piles near canneries. While these seedling rootstocks have been generally satisfactory, there is room for improvement in resistance to cold injury, longevity, productiveness, and disease and nematode resistance. On sandy soils in the southeastern states and in southern California, ordinary peach seedling roots are susceptible to nematode injury which may cause tree death within a year or two after planting if severe. Imported peach trees are being used for breeding stock by the U. S. Department of Agriculture and interested state institutions to develop nematode resistance; they include the Shalil (Figure 167) from India, Yunnan from China, and the Bokhara from Russia. Some promising hybrids have been developed. Roots of the almond, apricot, and Myrobalan plum have been used to some extent for

TABLE 15

Evaluation of Peach Varieties for Ohio (Adapted from Judkins)

(Additional information from different parts of the state may change the rating of varieties.)

Variety	Approximate Ripening Date (Wooster)	Flesh Color[1]	Hardiness of Buds[2]	Fruit Size[2]	Fruit Quality[2]	Fruit Firmness[2]	Stone Freeness[2]	Remarks
1. For commercial planting								
Cumberland	Aug. 14	W	1	3	2	3	2	Standard in its season
Golden Jubilee	Aug. 15	Y	2	2	2	3	1	Too soft for shipping
Halehaven	Aug. 27	Y	2	2	2	2	1	A standard variety
Belle of Ga	Sept. 6	W	1	3	2	3	1	Preferred to Champion
Elberta	Sept. 9	Y	3	2	3	1	1	Buds rather tender
2. For limited commercial planting								
Erly-Red-Fre	Aug. 5	W	2	2	3	3	2	Attractive, promising
Redhaven	Aug. 9	Y	2	3–4	2	2	1	Good except small
Oriole	Aug. 11	Y	1	3–4	2	3	1	Good in its season
Raritan Rose	Aug. 13	W	2	3	2	2	2	Firmer than Cumberland
Radiance	Aug. 17	W	2	2	2	3	2	Good after Cumberland
E. Halehaven	Aug. 17	Y	2	3	2	2	1	Good after Jubilee
Vedette	Aug. 23	Y	2	2	2	3	2	Good canner

Sunhigh	Aug. 25	Y	2–3	2	2	2	2	Promising
Redrose	Aug. 28	W	2	2–3	2	2	1	Promising
Midway	Aug. 30	Y	2	2–3	2	2–3	1	Promising
Eclipse	Sept. 1	Y	1	3–4	3	3	1	Fruit small
Summercrest	Sept. 5	Y	2–3	2	2	2	1	Color only fair
Kalhaven	Sept. 6	Y	2–3	3	2	2	1	Attractive, good shipper
White Hale	Sept. 10	W	2–3	1	2–3	2	1	Promising
Shippers Red	Sept. 11	Y	2–3	2	3	1–2	1–2	Many strains, some poor
Afterglow	Sept. 12	Y	2–3	2	2	2–3	1	Good after Elberta
Fertile Hale	Sept. 12	Y	2	2	2	2	1	Good in some areas

3. Varieties to satisfy special local demands

Mikado	Aug. 1	Y	1–2	3	3–4	4	3	Good in its season
Marigold	Aug. 4	Y	1–2	3	3–4	4	2–3	Good in its season
Goldeneast	Aug. 23	Y	3	2	2	2	1–2	Good if hardier
South Haven	Aug. 25	Y	2	2	2	3	2	Halehaven preferred
Colora	Aug. 25	Y	2	2	3	2–3	2	Halehaven preferred
Early Alberta	Sept. 6	Y	3	2–3	3	2	1	Buds rather tender
J. H. Hale	Sept. 10	Y	3	1	1	2	1	Tree lacks vigor
Gage Elberta	Sept. 11	Y	3	2	3	2	1	Buds rather tender
Lizzie	Sept. 20	Y	2–3	2	2–3	2	1	Promising
Iron Mountain	Sept. 20	W	2	2–3	2	2–3	1	Not attractive
Salberta	Sept. 25	Y	3	2	3–4	2	1	Good in its season

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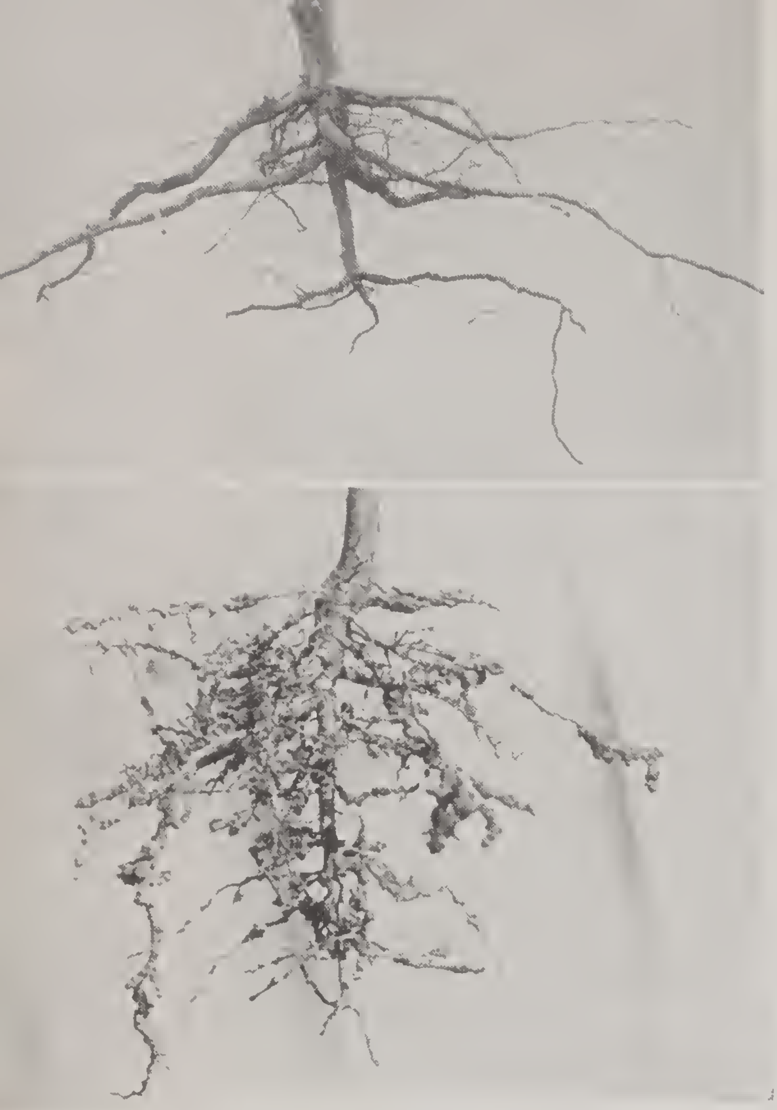
[1] Y—yellow; W—white.

[2] Numbers in columns indicate following:
(a) Hardiness: 1, very hardy; 2, hardy; 3, medium hardiness similar to Elberta; 4, tender; and 5, very tender.
(b) Fruit size, quality, and firmness: 1, very large, very high quality, or very firm; 2, large, high quality, or firm; 3, average or medium; 4, small, fair quality, or soft; and 5, very small, poor quality, or very soft.
(c) Stone freeness: 1, freestone; 2, a tendency to cling in some seasons; 3, semiclingstone; and 4, complete clingstone.

peach stocks in California, but none is entirely satisfactory.



Lee M. Hutchins, U.S.D.A.

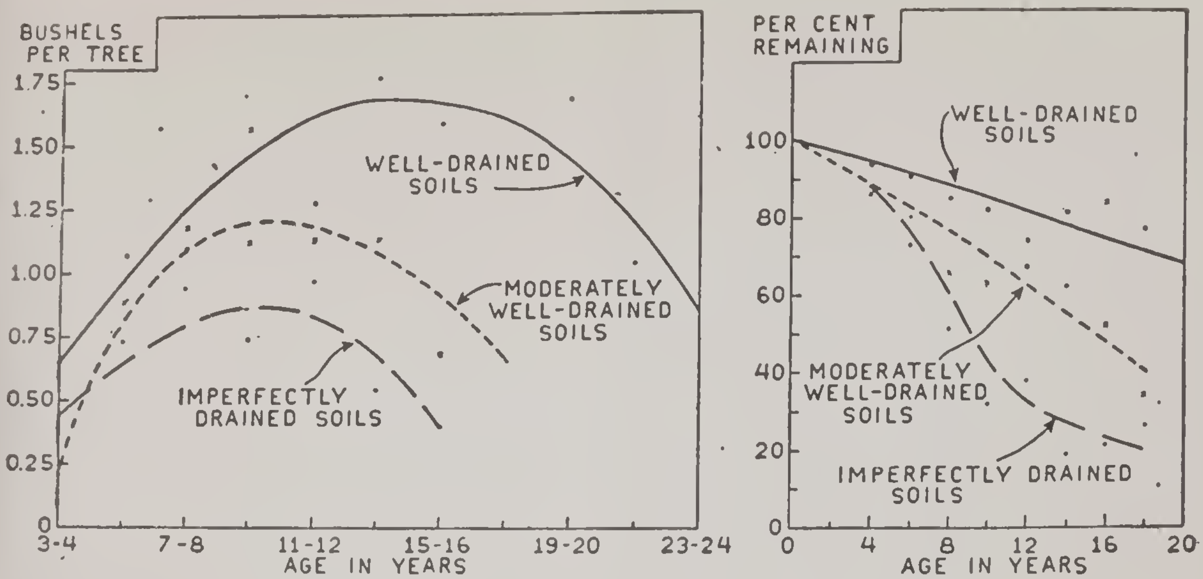
Figure 167. (Top) A Shalil nematode-resistant rootstock from India. (Bottom) A "natural" seedling nematode-susceptible stock from southeastern United States mountain area grown in Georgia.

PLANTING RECOMMENDATIONS

Although this subject has been covered for fruits in general in Chapter II, some special points should be made for peaches. While soil type is important (Figure 168), the choice of a good site is probably more important to the peach than any other fruit, especially east of the Rockies. Experience has shown that orchards planted on sites having good elevation are not so frequently injured by low winter temperatures as those on lower lands. Also, presence of top soil in Michigan has been shown to be extremely important in successful peach production. If by soil erosion, 75 per cent of the top soil has been lost from a site, yield is reduced almost half.

Peaches should be planted as early as the soil can be worked in spring in northern states; if planted late, a dry season may be encountered which is particularly disastrous with peaches. Fall and winter planting are generally practiced in the Southeast, particularly in the Carolinas and Georgia. Due to the fact that most peach orchards are planted on sloping land and receive some type of annual cultivation, it is becoming increasingly desirable that they be planted by the contour-terrace system, particularly if the land slopes from 5 to 15 per cent. If trees are planted on relatively level ground, a rectangular planting of about 24 by 18 feet is recommended in Michigan since this makes it possible to travel one way through the orchard shortly before harvest for the purpose of applying dust or sprays to control brown rot. Harvesting operations are also simplified. In California, a distance of 20 by 22 feet is considered most economical, while in Washington a wider spacing of not less than 25 feet is recommended using the square system.

From a commercial standpoint, peaches and apples should not be interplanted. This practice has been largely abandoned because (1) the spray programs for the two fruits are so conflicting that considerable loss and damage have frequently occurred to the peach trees due to arsenical injury, and (2)



T. E. LaMont and H. F. DeGraff, Cornell University

Figure 168. (Left) Relation of age of peach trees and soil drainage in New York to yield per tree, and (right) number of trees surviving. Difference in yield of trees on well-drained and imperfectly drained soils increases as trees grow older. Trees set on well-drained soil live twice as long as those set on imperfectly drained soils. Note, at 16 years of age, four times as many trees are living on well-drained soils as on imperfectly drained soils.

many of the most choice peach sites are often already occupied by apple orchards. If peaches and apples are to be planted together, it would probably be best to do so only on sites that are essentially apple sites. Choice peach sites should be retained for peaches only.

In the Pacific Northwest, certain precautions are needed for planting peach trees on land where apple trees have recently stood. This is because peach trees are susceptible to the relatively large amounts of arsenic in the soil as a result of the heavy arsenical spray programs for apples. It is suggested that peach trees be planted in the middles of the squares and between the rows where apple trees stood. In digging the holes, place the top and subsoil in different piles; replace the subsoil first, the top soil last. If possible, it is best to fill the hole with outside virgin soil.

PRUNING YOUNG PEACH TREES[1]

Pruning at planting. Most peach trees are trained to the open-vase form, although there has been some trend in recent years toward the modified-leader plan which requires a little more attention the first two years. The usual method for training one-year peach trees to the open-vase form after planting is to select three or four laterals which are well spaced both vertically and around the trunk. The lowest lateral should be about 18 inches from the ground and the highest lateral about 30 inches. This gives ample space under the trees for use of tractor-pulled disks. The laterals are cut back to short spurs two to four inches long, each containing one bud; all other branches are removed flush with the central trunk. The central trunk is cut back to one of the more vigorous upper branches, as shown in Figure 169. If there are no desirable upper laterals available, the peach tree whip should be headed back to the specified height of about 30 inches in order to induce lateral branches for a later selection. Do not cut the one-year trees shorter than 30 inches because it is difficult to treat the trees later for peach tree borers near the ground surface.

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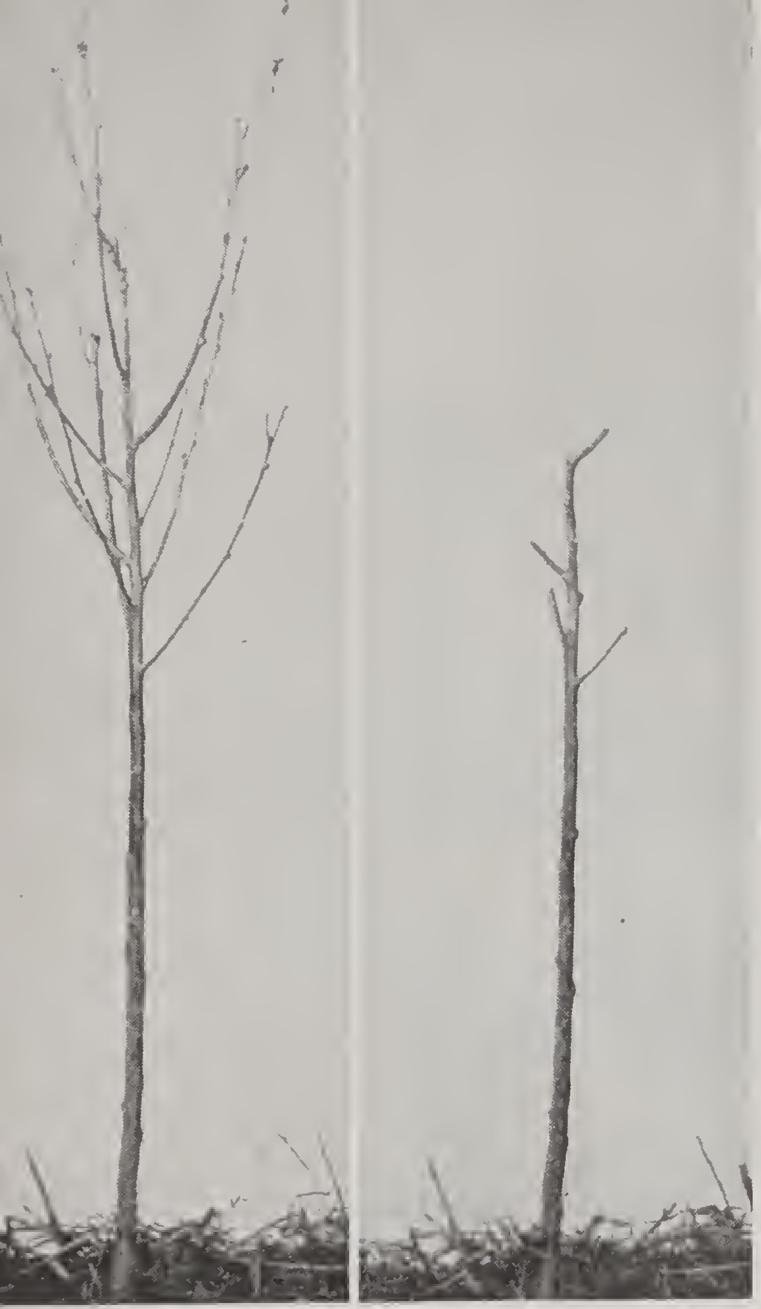
[1] See Chapter IV for principles and methods of pruning.

In some orchards of the Southeast and south central states, June-budded trees are set. Trees budded in the nursery in June and dug the same year for fall or winter planting are usually only two to three feet in height and may be more or less weakly branched. The side branches are frequently too low for framework use, and these are pruned flush to leave only a whip. Vigorous branches formed the second year are then selected for the scaffold.



F. H. Beach, Ohio State University Agr. Ext. Serv.

Figure 169. (Left) One-year peach tree after planting. (Right) Same tree after pruning. The tree was cut back to 30 inches. Four well-distributed side branches were left and cut back to short stubs to assist in developing a symmetrical open-center head.

The modified deshooting method. This method of training the newly planted peach tree has received increased attention in recent years, and has shown some advantages over the previously described system of training. Better selection of the lateral branches and somewhat better establishment of the head can be made. Also, the system has been found to reduce the amount of crotch injury from cold and the amount of trunk splitting due to too many scaffold limbs arising at the same point on the trunk.

A one-year peach tree of $\frac{9}{16}$- to $\frac{11}{16}$-inch diameter and five to seven feet in height is desired for this system. Small trees are unsuitable. The main trunk is cut off at 40 to 44 inches from the ground and all branches are removed below 15 to 18 inches from the ground. All other side branches are cut back to stubs of one bud each. In late spring or early summer, when the lateral shoots are four to eight inches long, as shown in Figure 170, four or five of the most desirably placed laterals are selected and the others removed. A vertical spacing of four to eight inches between laterals is desired; also, the laterals should be spaced around the trunk so each has an open space into which it can develop. Laterals which form wide angles with the trunk are the strongest; sharp-angled lateral branches should be removed. Some pruners desire to leave all the good-type lateral branches at this time and remove the others; the final selection of four or five strong laterals is then deferred until the following winter or early spring. Among the remaining four or five selected lateral branches, no one branch should be located directly over another. The stronger growing laterals are cut back to about the same length as the short laterals, with the lower branches left somewhat longer than the upper ones. The later pruning for this tree is similar to that described below for developing an open-bowl tree. The mature tree trained by this plan is shown in Figure 171.

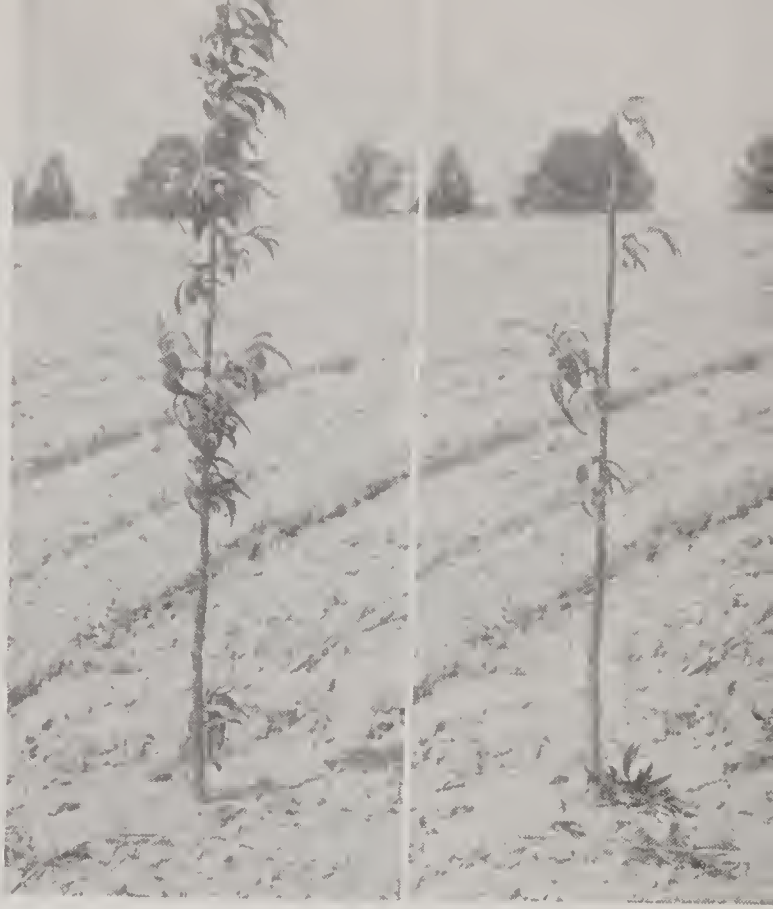
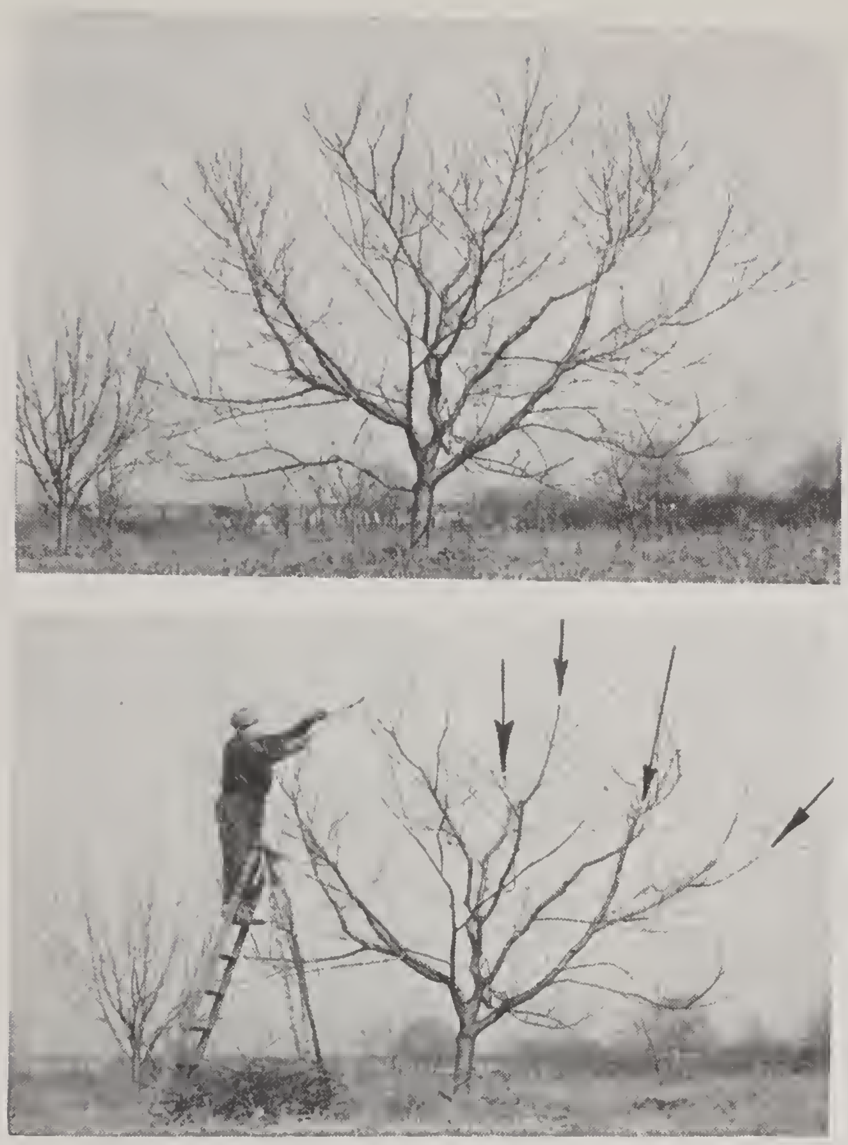

F. P. Cullinan, U.S.D.A.

Figure 170. Deshooting is on effective method of establishing strong-framework peoch trees. The vigorous one-year tree is cut to 40 to 44 inches at planting. Lateral limbs are cut back to one to two buds. When shoots are four to eight inches long in June, four or five well-distributed shoots are selected as shown ot right, others ore removed. Lowest shoot is about 20 inches above ground. Others ore six to eight inches apart.

Pruning the second year. In training the peach tree from the second year to maturity, *prune as lightly as possible to attain the desired shape.* It is a common mistake of growers to prune young trees heavily either in an attempt to develop stocky trunks or because of a misunderstanding of the effect of such pruning on subsequent growth. Actually, heavy pruning results in smaller trunks, delays commercial bearing for three or four years, and drastically decreases profits.

After the first season's growth, select the best four or five strong outward-growing scaffolds which are well spaced around the tree; most of these limbs will be the same ones which were selected immediately after planting. The branches should be spaced from three to six inches apart vertically along the trunk for the open-head tree and a little further apart for the modified-leader tree. Remove all other branches arising on the trunk. Remove any strong upright-growing central shoots, or, limbs that grow from one side of the tree across to the other side. The principal object is to train the tree to a symmetrical open-bowl tree, as shown later in Figure 171.

The lateral scaffolds which have been selected should be headed back lightly only where growth has exceeded about 30 inches with little or no branching. If length growth of the scaffolds is less than 30 inches and



F. H. Beach, Ohio State University Agr. Ext. Serv.

Figure 171. (Top) A 6-year Elberta peach tree with strong modified leader framework established by the deshooting system. (Bottom) The same tree in March or April in Ohio after pruning. The tips of all strong growing branches were cut back 12 to 24 inches to a side branch to keep the tree within a height and width spread of about 13 feet. The center was opened for light (medium-sized limb in center of tree will be removed in a few years). Lower limbs which tend to droop to the ground with fruit have been removed entirely or to an upward-growing lateral. Dead twigs in center of tree which may harbor disease also were removed. Wood removed is shown near ladder.

heavily branched, several thinning-out cuts will need to be made along the scaffolds. Two or three strong secondary laterals are usually sufficient at this age, with none left closer than 15 inches to the trunk. In this thinning-out operation, side branches on the scaffolds which grow toward the ground, toward the center of the tree, or straight to the sky are usually the first to be removed. Laterals on a scaffold limb which grow out and slightly up from the left and right are the most desirable.

In regions where Oriental fruit moth is a problem, the worms characteristically enter the tips of the growing shoots in early summer and stunt the length growth, causing many lateral branches to appear back of the injury. If this injury is excessive, the trees tend to become dense, necessitating several thinning-out cuts. With very dense vigorous young trees, some thinning-out during the summer may be helpful in speeding the development of a desirable framework.

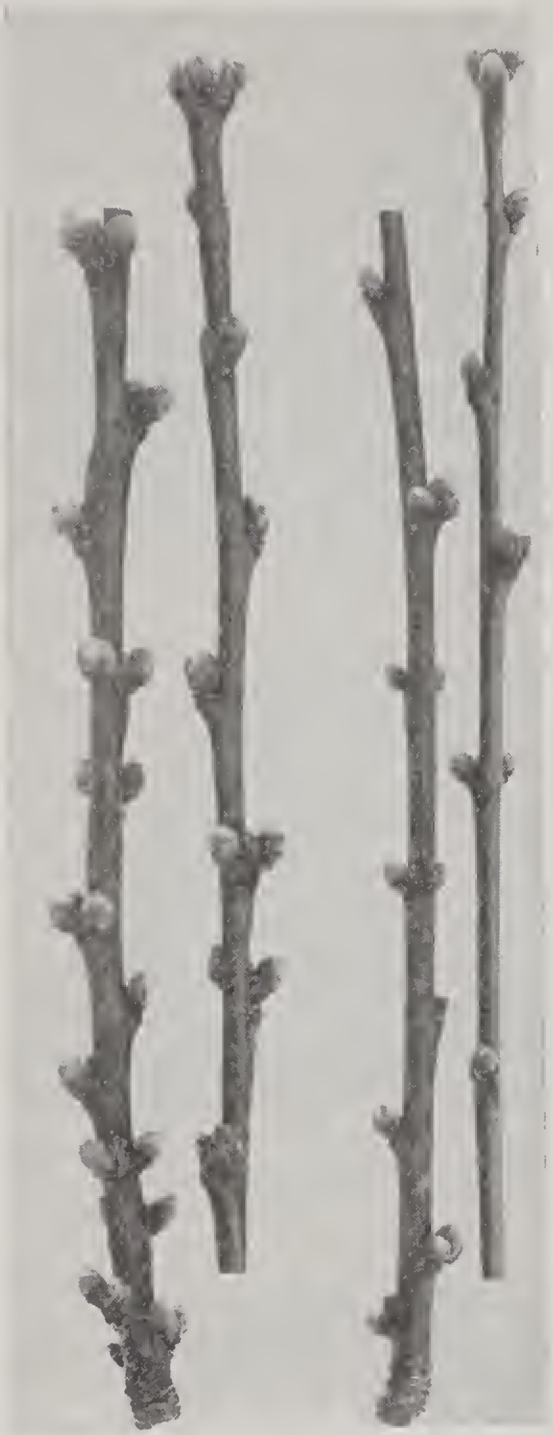
Special problems in starting the head. In some cases, a large part of the top may die in recently planted trees due to winter injury during the first year, or to an excessive dry period the first summer after planting. Under these conditions, a vigorous shoot may appear during the course of the season near the base of the tree and grow ahead of the originally selected trunk and laterals. This vigorous shoot can be used to develop the new head provided it arises *above* the point where the seedling root was budded in the nursery. A new framework is developed from this vigorous shoot, and the old head is removed flush with the base of the vigorous shoot.

Pruning the third year. If proper precautions have been taken previously, the tree should have its main framework well formed by the third year. Pruning will then consist largely of keeping the center of the tree open and spacing the lateral limbs and shoots on the main scaffold limbs. All short spurlike growth should be left which is not likely to become a competitive problem. These limbs contribute to fast development of the tree and are often the first to bear fruit. Therefore, they should be maintained until the tree becomes large, at which time they can be removed because of reduced vigor as a result of overshading and competition.

During the third summer, some thinning-out pruning may help to keep the center of the tree open, admitting more light for better fruit-bud formation in this area. Fruit buds of the peach are formed in late summer, later than those on the apple. If the pruning and soil management programs have received proper attention, some fruit buds should form the third summer for a light crop the following year. This is particularly true in southern states such as Georgia where the growing season is longer and the trees develop somewhat faster than in the North. There is considerable experimental evidence from Ohio and other states to show that heavy pruning of peaches in the third, fourth, and fifth years greatly reduces the yield. The peach tree usually does not attain its full size until the fifth or sixth year. Therefore, *light to moderate annual pruning attention* to attain strong desirable framework should be practiced so that the tree will attain its full size and production as soon as possible.

PRUNING THE BEARING PEACH TREE

Bearing habit. Peach trees bear fruit laterally on wood that grew the previous year. Therefore, the terminal and lateral shoots which have developed over the outer surface of the tree are the most important in fruit production. The best and most fruit is produced in the upper third of the tree. If the practice has been followed of leaving the center of the tree relatively open, as shown in Figure 171, a considerable number of new shoots and short growths or spurs will develop also near the center of the tree. The open-bowl type of head should be maintained, and the height and width of the tree also should be kept within easily managed bounds. About a 13-foot height and a 13-foot spread is considered an acceptable size. Fruit buds of the peach are plump and roundish; on the other hand, the leaf or shoot buds are small, narrow, and pointed (Figure 172). On the vigorous shoots, fruit buds at a given node may occur in numbers of one, two, or three, depending upon the variety and tree vigor. Where three buds are at a node, the usual arrangement is for the center bud to be a leaf bud while the two outer buds are fruit buds. On the shorter growths and spurs, fruit buds are often borne singly beside a leaf bud. On very vigorous shoot growths of 30 inches or more, the lateral buds may consist almost entirely of leaf buds, particularly on the lower portion of such a shoot.



M. A. Blake, New Jersey Agr. Exp. Sta.

Figure 172. (Left) A thick vigorous annual twig of Elberta peach cut in two sections. (Right) A relatively thin twig of the same variety cut in two sections. Note that the fruit buds on the left shoot are larger and more numerous. Thick wood also is capable of producing more and larger leaves and fruit. (Where three buds are located at a node, the center bud is usually a leaf bud.)

Well-grown bearing trees seldom fail to make enough fruit buds for a heavy crop of fruit the following year. Ordinarily, far too many fruit buds are produced and, therefore, dormant pruning is helpful in thinning the crop as well as inducing proper renewal of fruiting wood throughout the tree. If a bearing peach tree 8 to 12 years of age is making from 12 to 16 inches of shoot growth on the majority of the outer branches, this is sufficient for maintaining good fruit production.

Bearing peach trees *must be pruned every year.* If regular annual pruning is not performed, the tendency is for the fruiting wood to develop further and further out and higher up each year. Eventually, a thick-topped leggy tree develops almost devoid of low-fruiting wood. In order to bring such a tree down into economical range and fruiting, it will be necessary to make some heavy heading-back cuts on the main limbs which may destroy a large part of the crop in the first and second years following.

When and how severely to prune. In regions where winter killing of wood and buds is a factor, the presence or absence of freezing damage more or less governs the pruning procedure with bearing peach trees. If the temperature reached 10° F. below zero during the winter, at least some and perhaps all fruit buds may be killed. In the Southeast, a temperature of —10° F. could be expected to cause more damage than in the North unless the trees had been hardened by cold weather sometime prior to this low temperature. The critical temperature for dormant peach wood in northern states is around 20° below zero, although there may be considerable variation in amount of injury, depending upon the variety and previous growth conditions. Winter injured wood can be identified by a browning of the inner sapwood to the pith. Fruit buds killed by low temperatures have dark brown centers when cross-sectioned. Some estimate of the damage can be obtained by sectioning 50 to 100 buds on each variety in different exposures in the orchard.

In northern states in small orchards, it is best to delay pruning until after danger of winter killing of buds and wood is passed. This is at least until late February or early March in the region of central Ohio. If there has been no winter injury to the fruit buds, a general over-all pruning is then recommended. If a portion of the buds has been killed, a relatively light pruning should be given because heavy pruning may reduce yield without improving quality. Under most conditions, however, the majority of the living buds will be found on wood in the top of the tree; pruning in this area, therefore, should be relatively light and so-governed to make the best of the prospects.

If practically all of the fruit buds appear to be killed in small orchards, delay pruning until blossoming time. If no blossoms appear, use this opportunity to thin out and moderately cut back in order to keep the tree within desirable height and spread. Special attention should be given also to proper branch distribution in order to evenly space the fruiting wood throughout the tree.

If the orchard is large, the grower must proceed with his pruning regardless of possible cold injury in order to completely cover his orchard. In the Middle Atlantic states, in most years it is safe to prune any time during the winter when most of the work is commonly done.

In regions where spring frosts are a greater risk than winter injury, the necessary thinning-out cuts can be made during the dormant season, but the amount of heading-back cuts is better deferred until after danger of frost injury is over. At this time, the degree of heading-back which is needed can be done with more certainty.

If the crop is lost entirely and the wood is severely injured, there may be temptation on the part of some growers to "dehorn" the trees. "Dehorning" is a term used to describe large heading-back cuts four to six feet or more from the tips of the branches, leaving little more than stubs of the main branches. This practice was recommended back in the early 1900's, but experience has shown that these large cuts drastically reduce the crop for several years and may be fatal or severely weakening to the tree. The best treatment for severely winter-injured trees is to not prune, or, to prune lightly after growth starts, in combination with an early and rather heavy spring application of a nitrogen fertilizer, such as nitrate of soda. This should be accompanied by cultivation, if possible, to restore growth conditions. After growth starts, the dead wood can be spotted and removed immediately. If the trees recover, a moderate amount of pruning can be made the following spring to lower, thin out, and spread the top.

If uninjured peach trees are heavily dehorned, the resulting growth is so rank that it is difficult to properly train the tree. This heavy pruning also practically eliminates bearing for two or three years. A moderate amount of dehorning may have a place in cases where the trees have become "leggy" from neglect and the crop has been killed, but the wood uninjured. The large cuts should not be made in wood older than three or four years. All heading-back cuts should be made to prominent side branches on which rather light heading-back also is given. When some dehorning is practiced, the vigorous upright branches should be removed entirely which, in some cases, may be growing into and through the center of the tree. All cuts should be directed toward forming a low open and spreading type of framework.

Placing renewal cuts. As a tree reaches the height of about ten feet, it is important to cut the main upward-growing branches back to outward laterals, as shown in Figure 171. The point at which this cut is made is known as the "renewal point" near which similar cuts will be made in future years. A renewal cut should be placed at the end of every main branch as soon as it reaches sufficient height or width spread. The summer after this type of cut is made, one or more side shoots will appear below the cut. During the next winter pruning period, the more vigorous and outward-growing lateral of these can be retained; the other branches are removed, including the large side branch left the year before. Some growers make these first heading-back cuts on a tree when it has attained a height of eight feet. While this may somewhat reduce the bearing surface of a tree, in subsequent years it is possible for the workmen to make most of the renewal cuts without a stepladder. Also, with the bearing surface closer to the ground, the harvesting and thinning operations are facilitated. However, on soils and under cultural conditions which promote development of large trees, it may be necessary as some trees grow older to do a considerable amount of pruning and other work from stepladders.

General recommendation. Peach pruning should be somewhat lighter during the first three or four years after the trees come into bearing. Later, a somewhat heavier heading-back type of pruning is desirable every third or fourth year in order to keep the bearing wood low. When the bloom has evidence of being heavy, the thinning-out pruning will assist considerably in reducing the need for hand thinning of the fruit later. However, this thinning-out pruning should not be excessive to the point of reducing yield.

Dormant pruning throughout the tree should be sufficient to admit several sun spots on the ground beneath the tree during the growing season. Thick annual terminal growth of 10 to 15 inches is desirable for maintaining good production and sizing of the fruit. The pruning, fertilization, and soil management programs must be carefully interrelated to promote this type of terminal growth. Short slender shoot growth is generally unproductive and is characteristic of declining trees (Figure 172). On the other hand, trees which are overly vigorous and producing annual growth of over 30 inches are not only less productive but are difficult to manage in pruning. The accumulation of many dead twigs in the center and lower part of a tree is good evidence of too little pruning throughout the top center of the tree.

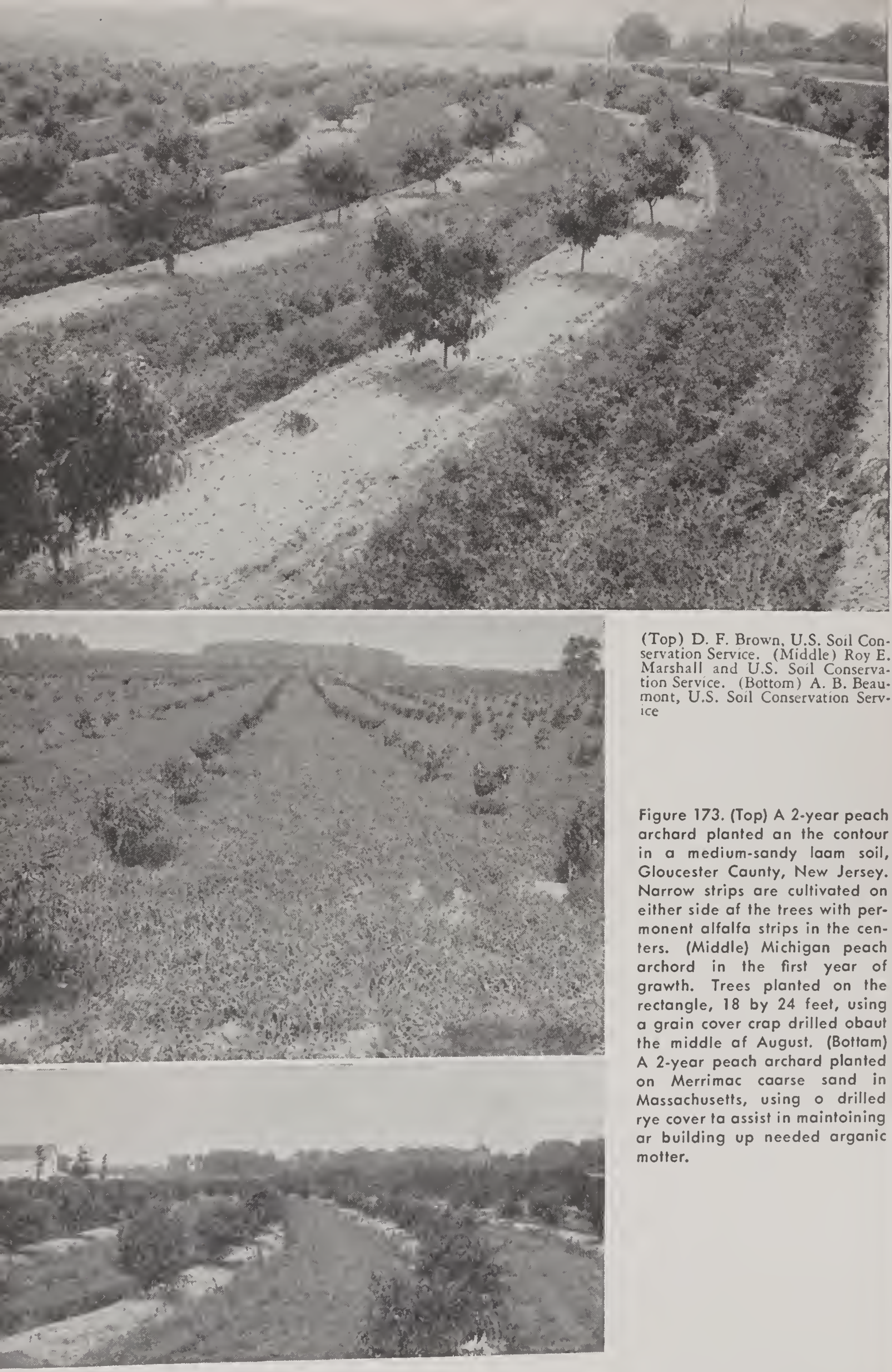
Bracing limbs. Weak crotches are often found in the peach orchard, and this in itself may be evidence that the modified-leader type of tree should be encouraged more than it has been in the past. If the lateral branches have been allowed to become leggy and long, the leverage of a crop of peaches at the end of these branches may be severe, causing them to split away from the trunk. A method for bracing these crotches with wire and screw eyes has been described in Chapter IV.

SOIL MANAGEMENT

Young trees. Some form of cultivation should be provided for young peach trees for at least the first two or three years after planting in order to obtain good survival, vigorous growth, and earlier commercial production. Common systems of management for young trees are shown in Figure 173. If the orchard is planted on the contour, either the entire middles or only narrow strips on either side of the trees can be cultivated during the spring and most of the summer, discontinuing cultivation about the first or middle of August or earlier. Middles of the rows may be sown at the outset to a semi-permanent cover crop such as alfalfa, or they may be sown each year to a summer and winter cover. If the land is fertile and suitable to the growing of intercrops such as vegetables or small fruits, such a practice is feasible and it affords cash income until the peaches start bearing the fourth or fifth year.

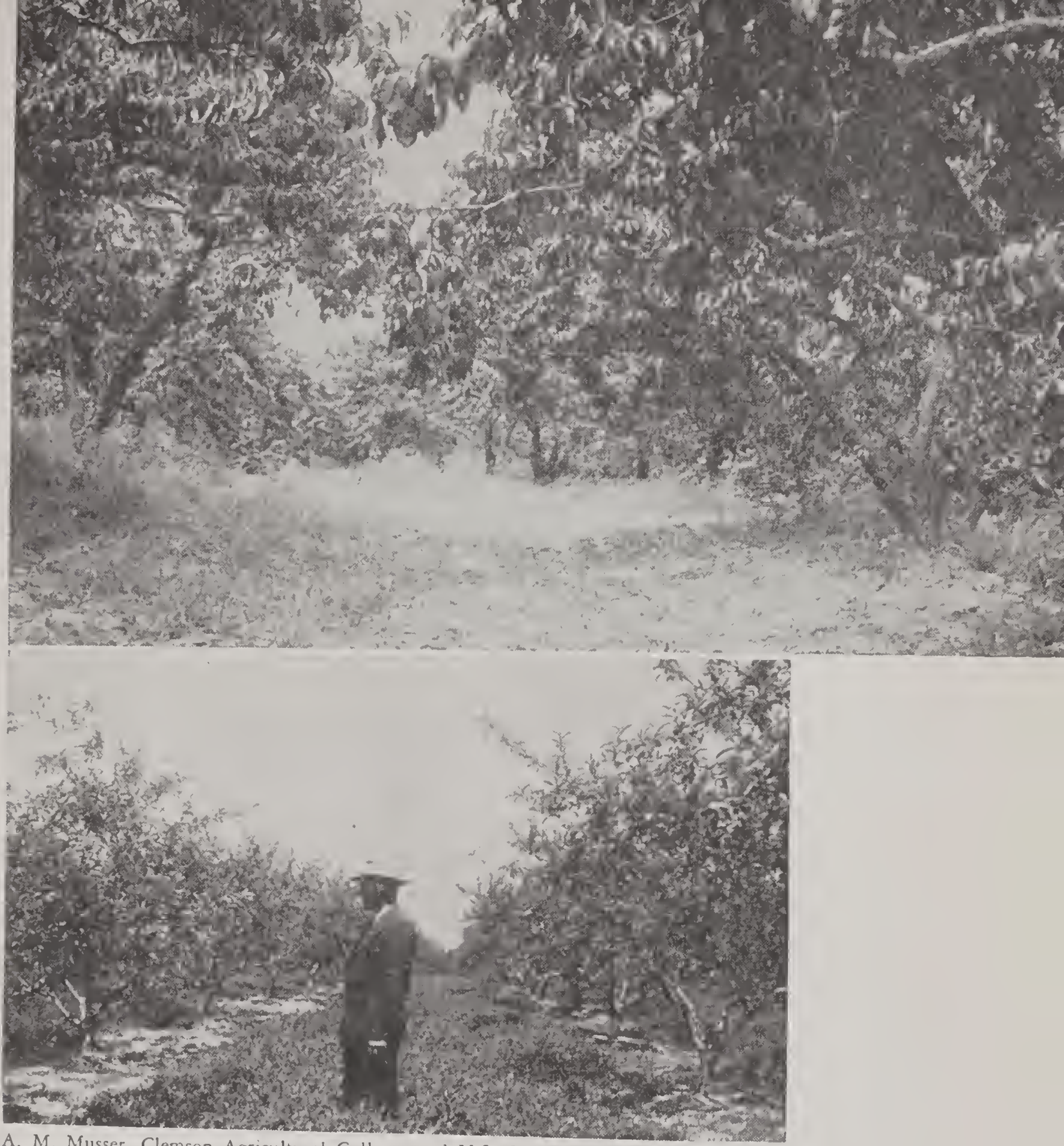
During the first two or three years in an orchard, summer cover crops are often planted if some cash intercrop is not grown. These are sown in early June. Soybeans or cowpeas are commonly used, both in the North and South; in the South, crotolaria is also popular. These are disked into the soil about the first to middle of August in preparation for a winter cover.

Winter cover crops, such as rye, rye grass, or wheat should be sown about the middle of August to the first of September in northern states. Hairy vetch, Austrian peas (Figure 174), or rye are popular in the South and are sown about the middle of August. Where the winter cover crop is a grain, it is important that disking or mowing be done early the following spring, preferably when the growth is about knee high and before it has had opportunity to compete with the trees for water and nitrogen. This is especially true for rye which may grow so fast in spring that it is difficult to complete disking before the crop has interfered with growth of the trees. The danger of such a situation in humid regions is not great, however, if adequate nitrogen has been applied for both the cover crop and the trees. If the land is sloping and not contour-planted, it is important that all cultivation be performed across the slope and not up and down the slope.



(Top) D. F. Brown, U.S. Soil Conservation Service. (Middle) Roy E. Marshall and U.S. Soil Conservation Service. (Bottom) A. B. Beaumont, U.S. Soil Conservation Service

Figure 173. (Top) A 2-year peach orchard planted on the contour in a medium-sandy loam soil, Gloucester County, New Jersey. Narrow strips are cultivated on either side of the trees with permanent alfalfa strips in the centers. (Middle) Michigan peach orchard in the first year of growth. Trees planted on the rectangle, 18 by 24 feet, using a grain cover crop drilled about the middle of August. (Bottom) A 2-year peach orchard planted on Merrimac coarse sand in Massachusetts, using a drilled rye cover to assist in maintaining or building up needed organic matter.



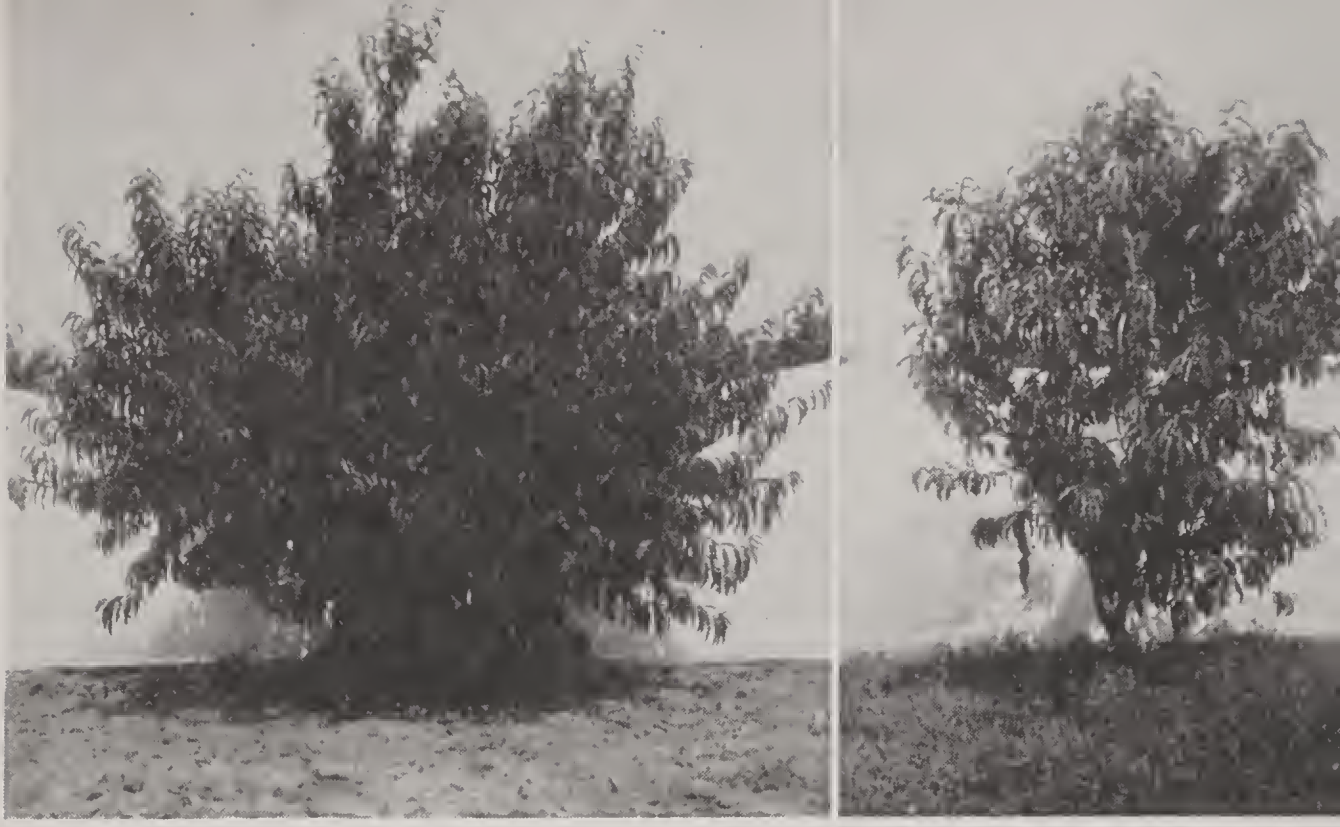
A. M. Musser, Clemson Agricultural College, and U.S. Soil Conservation Service

Figure 174. (Top) Oldest peach orchard in South Carolina planted in 1901. Rows were on contour; bench terraces have been gradually built up. Slope averages from 6 to 15 per cent. Trees are still vigorous and produce from 350 to 400 bushels per acre. (Bottom) A good stand of Austrian winter peas in South Carolina. Hairy vetch, rye, and Crotalaria are also popular in this region. Winter covers are more important in the South than the North because the ground does not freeze, making winter erosion a problem.

Bearing trees. Where cultivation is practiced in bearing peach orchards, some type of cover cropping is recommended in order to maintain or increase organic matter in the soil, reduce erosion, and to reduce the possibility of winter injury. Shortly before or after bearing has started, however, it may be desirable to shift the soil management program from a cultivation cover-crop system to some form of sod management, depending upon the soil type and rainfall conditions in the region. It is generally agreed among horticulturists that cultivation should be reduced to a minimum; there is considerable evidence accumulating to show that excessive cultivation is eventually detrimental to the soil and to tree growth. What the minimum amount of cultivation should be cannot be stated definitely; it may vary from orchard to orchard, depending upon the slope of the land, the fertility, and the moisture retaining capacity of the soil. For example, an orchard on a fertile soil with high moisture retaining capacity might be managed to a good advantage under a system of semipermanent sod with or without mulch, which is disked in the spring and allowed to grow with one or two mowings in summer, especially if dry periods occur. On the other hand, an orchard on a lighter and somewhat more infertile soil probably could not be handled successfully by this method. Undoubtedly, under sandy soil conditions as often found in the Southeast, it would require longer periods of cultivation to remove competition between the trees and the cover crop for moisture. Heavy clays may be entirely unsatisfactory because they present a drainage problem and are likely to be too wet at times and too dry at others.

If a semipermanent cover is desired, such as shown in Figure 175, it is well to consider annual rainfall as well as the moisture retaining capacity of the soil. Such a system undoubtedly would have more chance to succeed under annual rainfall conditions of about 50 inches or more, as compared with 30 inches or less.

A system of management for peaches, receiving increased consideration is sod mulch plus additional mulch from an outside source. There is clear evidence from experiment stations in the Northeast that peaches can be grown satisfactorily under sod mulch in the moderately heavy types of soil, provided a heavy mulch is maintained and two and three times the nitrogen is applied as recommended under cultivation. It is a common mistake among growers to mulch thinly due to the fact that mulch material is scarce and comparatively expensive in commercial fruit-growing areas. Such a mulch cover is little better than none. Maintenance of a cover of eight to twelve inches under the spread of the branches is usually recommended; the more the better within limits (Chapter V). With a mulching program, one must consider the danger of mice and fire. Also, certain insects are more troublesome in sod orchards, particularly while the young fruits are developing to about one inch in diameter. Insects include the curculio and Oriental fruit moth (worms in fruit), tarnish plant bug (dimples the fruit), and the Buffalo tree hopper (scars young wood). Although mowing the weeds and



E. F. Savage, Georgia Exp. Sta.

Figure 175. Four-year June Elberta peach trees at Experiment, Georgia. Typical trees on (left) clean cultivated plot and (right) on adjoining alfalfa sod plot. Alfalfa is deep-rooted and competitive for moisture; it should be kept a few feet from the tree trunk and used only in regions of adequate moisture or where irrigation is available. Both trees were well fertilized with nitrogen.

cover will reduce these insects, control is usually not as good as with cultivation during the early spring months.

On sloping land which has not been contoured, it may be desirable to leave narrow strips of sod in the tree rows across the slope, cultivating the center strips early in the spring and summer, and sowing them to a winter cover crop in August. It has been demonstrated that these narrow sod strips have little influence on yields and do not materially increase the disease and insect problem. The width of the sod strips would depend largely on the erosiveness of the soil. Cultivation between the rows in any event should be only enough to discourage weed growth until a cover crop is sown.

The size of the peach crop more or less governs the time of seeding the cover crop in late summer. If the trees are carrying a light or no crop, the cover can be sown earlier for the purpose of competing with the tree, reducing its growth, and thus reducing the likelihood of winter injury. On the other hand, if the trees are carrying a heavy crop of fruit and the weather is somewhat dry, the cover crop can be sown later in September in order to reduce competition for water with the maturing crop of peaches.

Rye grass and wheat have been popular winter cover crops in bearing orchards in the Northeast because they grow more slowly in spring and give the grower opportunity to mow or disk them down before they compete heavily with the trees. Rye is a popular cover crop because the seed is cheap, available, and will germinate and take hold better under adverse conditions. Sudan grass is frequently used but it has the objection of growing too rapidly shortly after sown in August, thus competing with the trees. It also may become so high as to interfere with the harvesting operations unless mowed.

Fertilization, with or without lime, of the cover crop at seeding time is now being generally practiced to obtain good covers. Most cover crops and especially legumes grow best in soils with a pH of about 6.0 to 7.0. Rye will grow on soils too acid for other cover crops. An application of 100 to 150 pounds per acre of a high-grade complete fertilizer is recommended on areas where the cover is sown, using a 4–16–4 for loamy soils of moderate fertility and a 10–6–4 for sandy soils, or those of low fertility. Adequate fertilizer must be applied for both the trees and nonlegume cover crop in order to avoid much of the so-called "damage" to the trees by the cover crop.

Fertilization. Barnyard manure is highly effective in producing the desired results for peach trees, but it is relatively scarce. If manure is available, it should be applied lightly at the rate of five to eight tons per acre in the fall or winter. Heavy applications in the spring may cause the trees to grow too late in the fall. It is well to apply manure cautiously, and too lightly rather than too heavily.

By far the majority of peach growers rely on commercial fertilizers as a source of nutrients. Nitrogen is the element which gives the best response in peach trees; in some soils it may be the only element needed. In fact, for a given amount of nitrogen, more response is obtained in peach trees than almost any other fruit crop.

Application of nitrogen should be governed entirely by the character of the shoot growth. If young peach trees are making approximately 18 inches of terminal growth and the foliage is of good color without fertilizer application, they do not need fertilizer. The same can be said for bearing orchards if the annual shoot growth is 10 to 15 inches, the girth of the shoots is thick, and the buds plump. If the growth exceeds this length for mature trees by several inches, it would be well to reduce the nitrogen or eliminate it entirely for awhile. There are many instances of where careless use of nitrogen fertilizer on peach trees has resulted in great damage by overstimulating the trees, and inducing winter injury which later provides entrance for diseases and insects. *Each tree should be considered separately as to its fertilizer needs.* Trees growing on the lower more fertile areas will require less fertilizer than those growing on somewhat eroded knolls.

It is difficult to recommend a definite amount of nitrogen-carrying fertilizer for a given orchard, or, for a given peach tree. When growth of the trees has been uniform, the problem is much easier. However, tree growth in most orchards tends to be quite variable. Ordinarily, sulfate of ammonia, ammonium nitrate, or cyanamid is used each year at the rate of one-fourth to one-third pound per year of age of the trees. About 5 per cent more of nitrate of soda is used. Cyanamid should be applied in the fall to avoid burning, especially on light soils. When the trees have reached maturity after about six years, the application thereafter is three to five pounds per tree of sulfate of ammonia or its nitrogen equivalent, depending upon annual shoot growth, amount of pruning, condition of the tree, and type and native fertility of the soil. On the basis of pure nitrogen, this is about one-half to one pound per mature tree.

The grower should study his orchard carefully in order to maintain the proper amount of growth, and no more. With peach trees, it is much safer to make a mistake by applying too little fertilizer than by applying too much.

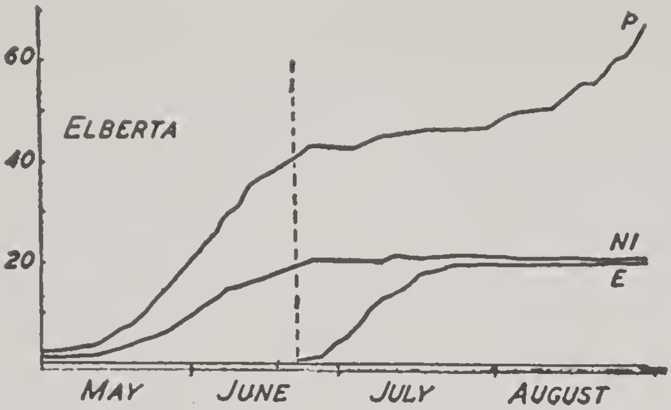
There is evidence in Michigan, New York, Indiana, and other states that potassium may be deficient under some conditions and in limited areas. This is characterized by limited growth with curling leaves which show considerable tip and marginal burning. The grower can experiment himself by applying the usually recommended amounts of this and other elements which are likely to be deficient in fruit trees (Chapter V).

Irrigation. Peach trees respond well to readily available water throughout the growing season. Fruit which has fallen behind in size because of insufficient moisture during the growing season will never regain the size obtained on other trees receiving adequate moisture. Irrigation is a regular practice in peach orchards along the Pacific Coast where low rainfall makes it a necessity. In the East, however, irrigation is not common, although there are no doubt many instances where it would pay dividends. Contour-terraced peach orchards are well adapted to irrigation, as pointed out in Chapter II.

The moisture content of the soil should not be allowed to reach the wilting point in the region where the tree roots are functioning. In California if winter rains have not been sufficient to wet the soil to a depth of five or six feet, a spring irrigation is often made to give the trees a good start. For mature trees, the length of time between irrigation varies from about three weeks on sandy soils to six weeks on loam soils. In Washington, irrigation begins about April 15 and continues thereafter every 7 to 20 days during the growing season, depending upon the depth and type of soil. Irrigation is often practiced during the picking season in Washington because the peaches take on enough water overnight to keep them firm when the weather is hot and dry. During each irrigation, the soil should be wetted to a depth of five or six feet. Excessive use of irrigation, however, must be avoided because a high water table not only seriously limits root development but may cause accumulation of alkali in the upper soil layers in the alkali regions of the West. The ground table should be maintained at least six to eight feet below the surface. Special precaution is necessary to avoid using irrigation water relatively high in alkali salts.

THINNING PEACH FRUITS

Fruit thinning is a standard practice on peach trees carrying a moderate to heavy crop. However, in spite of the many benefits from thinning which have been demonstrated through long years of experience, fruit thinning is too often one of the most inefficiently conducted operations in peach grow-



H. B. Tukey, New York Agr. Exp. Sta.

Figure 176. Growth curves of Elberta peach from full bloom to maturity for *P*, pericarp or edible part; *NI*, nucellus and integuments of pit; and *E*, embryo in the pit. Note period of about five weeks after dotted line and during embryo development when the edible part, *P*, shows little increase in size. Length of period from full bloom to dotted line is about the same for early, medium, and late varieties, but period from dotted line to final increase in fruit size may vary from a week for an early variety (Greensboro) to six weeks for a late variety (Chili).

ing. Johnston gives the following reasons for growers slighting this job: (1) failure to realize at thinning time how much the young fruits will expand in size before the harvesting season if they are given the proper opportunity; it is important to consider that it takes twice as many peaches of two-inch size as of two and one-half-inch size to fill a bushel basket; (2) failure to realize that it is better economy to pick the excess fruits after the June drop and throw them on the ground than to be compelled to pick them at the regular harvesting season with the resultant extra handling costs and lower value of a crop of small peaches; and (3) thinning is a monotonous job and it is only natural to hurry through or to find excuses to do something else. Thinning crews must have constant and careful supervision for best results.

The best time to start commercial thinning is immediately after the June drop. The extent of the thinning task can be determined better at this time than earlier because peach trees generally retain practically all fruit to maturity which are attached to the tree after the June drop. Where certain insects are a problem, most of the injury is over by this time, and damaged peaches can be removed in the thinning operation. There are other advantages in waiting until after the June drop to thin: (1) The difference in size among the fruits becomes more pronounced and a better selection of the larger fruits can be made, removing the smaller ones; (2) A better idea of the sizing ability of the tree and a more uniform and accurate distribution of the fruit may be had; (3) A larger proportion of culled fruit can be removed; and (4) Less labor is required for removing the fruit, making it possible to thin more trees per day.

The early maturing varieties should be thinned first. Next, thin the varieties and the trees within a variety which are carrying the heaviest crop. In order to obtain the greatest benefit from thinning, the job should be completed as soon after the June drop as possible, although it has been shown that for many of the medium- to late-maturing varieties, some benefit from thinning can be obtained as late as eight to ten weeks before picking. The ability of a peach tree to develop size in its fruit depends upon (1) the crop that the tree is carrying at thinning time, (2) upon the vigor of the tree, and (3) upon the water available throughout the growing season.

The commonly recommended distance for thinning peaches along a shoot is from six to eight inches, depending upon the size naturally attained by the variety being thinned. With some varieties, such as Rochester, which set heavily and inherently produce small to moderate size fruits, it is necessary to space the fruits farther apart. However, with Elberta and J. H. Hale which tend to produce larger fruits even though somewhat crowded on the branches, individual fruits may be left closer together. This method of thinning may be fairly successful in the hands of a grower who by experience knows how many peaches of first-grade size can be produced on a tree growing under his climatic and soil conditions.

In California, an attempt is made to grow fruits as nearly uniform in size as possible for canning purposes. In thinning, a more or less definite number of peaches is left on a tree of given vigor and size. The number of peaches of a given size which a mature peach tree will develop is determined by the grower on the basis of his experience with the ability of his trees to size the fruit. A grower usually has a fairly accurate idea of what tonnage his orchard should produce. As an example, he may decide to grow two and one-half-inch peaches, and from experience he knows that each tree is capable of producing about four bushels of fruit. The following table shows the number of fruit per bushel for given sizes of fruit.

Diameter of Peach	Peaches in Bushel
2 inch	380
2⅛ inch	315
2¼ inch	280
2⅜ inch	225
2½ inch	190
2⅝ inch	165
2¾ inch	145
3 inch	110

From the above table, it would require about 190 peaches of two and one-half-inch size to make a bushel. This means that the thinner should leave about 750 peaches per tree to obtain the desired yield. Actually, about 800 peaches should be left to provide for loss from insect injury and to replace a few peaches on the tree that for one reason or another do not attain marketable size. If the thinners attempt to leave about 750 peaches per tree, however, they probably will leave closer to 800 because of the tendency of almost all thinners to leave more peaches on the tree than they should.

Thinning by count does not necessarily mean that peaches on every tree are counted. At the outset, a well-trained foreman can demonstrate to the crew the approximate number of peaches to leave on a tree of average size for each variety. The thinners bear this general spacing and crop size in mind and, if necessary, they can go back and check the demonstration tree to revisualize the spacing. No method is fool-proof; good judgment is needed with every method.

In the Northwest, about 80 to 85 average-size peach leaves are required to properly size and mature a single peach, whereas somewhat less foliage appears necessary for good commercial size in the East.

The largest and best-colored peaches are produced on the more vigorous new wood. Therefore, more peaches should be left on the outside and especially in the tops of the trees than on the inside and lower branches. Fruit on "hanger"[1] branches around the lower part of the tree should be thinned more heavily, perhaps picking all fruits from thin weak wood.

Effective methods for thinning the blossoms of peaches have been tried but as yet they have not been extensively used in commercial orchards. Elgetol when applied at full bloom at a concentration of one-half to one pint in 100 gallons may reduce the set from none to a satisfactory amount, depending upon the variety and condition of the trees. A concentration of one pint per 100 gallons may be satisfactory on moderately vigorous trees blossoming rather heavily. The use of one and one-half pints per 100 gallons usually thins too severely.

In Georgia and the southeastern states, what is known as "brush thinning" has been performed successfully at blossoming time. This type of thinning was encouraged during the war when labor was scarce. The brush which is bushy at the end consists of one or two dogwood or apple branches, three-fourths to one inch in diameter at the base. The branches are tied together giving a broom effect. Another type of brush consists of a 12- to 18-inch piece of broom handle with three-inch pieces of 14-gauge wire tacked to the end and flared to a width of three or four inches. The wires are held in place on the wooden handle by grooving and wrapping tightly with wire or by slipping a short piece of pipe over them. The operator uses one or two of these brushes, starting the thinning operation at the blossom-balloon stage and continuing until shortly after full bloom. During the war, six cents per eight-year tree was paid to teen-age boys who could thin about 65 trees in a day. With this type of thinning, it is necessary to break up the clusters by hand after the June drop. This cost about four cents per tree.

The thinning job has been speeded up after the June drop in some eastern states by using two broom handles with six inches of rubber hose placed over the ends. One handle is about two feet in length and the other about 40 inches. A stick is held in each hand. Peaches are knocked off with the rubber ends, using either the long or short stick, depending upon the reach. By this method, thinning is more rapid, costs are reduced, and while the quality of the thinning may not be as high, the operation itself is simplified.

HARVESTING PEACHES

Because the first peaches on the market bring good prices, there is a tendency among eastern growers to flood the early market with immature peaches. Green, hard, starchy, shriveled peaches receive little or no demand and consequently, the price often drops quickly. If the consumer were given his choice, he would prefer that the peach be removed from the tree at the peak of its color and quality. The grower, on the other hand, cannot afford to wait until the peach reaches this stage of ripeness because such peaches bruise easily, lose condition rapidly, and may result in considerable loss during the handling operations. The grower knows that firmness is a primary factor in safety of handling; the degree of firmness at which the peach should be harvested depends upon the variety, size of the crop to be handled, and distance to the market.

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[1] In the East this term refers to wood which has fruited for several years and become low-hanging and unproductive, whereas in California it means branches arising from the main limbs on heavily cut back stubs. These produce good size fruit.

Probably the best time to harvest peaches is just as the ground color is beginning to change to yellow for yellow-flesh peaches or to white for white-flesh peaches. Also, just prior to maturity, there is a swelling of the flattened sides of a peach. It is usually necessary to pick the trees more than once during the harvesting season in order to attain the desired degree of ripeness. Some growers go over the trees "spot" picking two or three times, each time removing the fruits which are of first-grade size and color. Other growers may go over their trees five to ten times, removing only the largest, best-colored fruits and leaving the smaller ones to gain size and color before being picked. Maximum yields of first-grade fruits can be obtained by this method. Growers who attempt to harvest all the fruit at one picking obtain many small and immature peaches. On the other hand, if the picking is delayed too long, many of the fruits will be harvested overripe.

In the middle and south Atlantic states and the West where the fruit may be shipped as far as New York, Chicago, or further, the growers usually pick the fruit about 36 to 48 hours before it would be ready to eat. This is under average weather conditions. If the weather has been cool and suddenly turns hot and muggy, ripening will be speeded up considerably. On the other hand, if weather has been hot and turns cool shortly before harvest, the ripening may be retarded.

The variety must be considered. Champion, for example, ripens so quickly and deteriorates so rapidly that it is not well suited to shipment and should be sold locally. Hiley, in comparison, ripens much more slowly and may be left on the tree longer after it begins to show signs of maturity. Elberta is adapted to long shipment but must be picked promptly at a certain stage of maturity to avoid loss from dropping. With a little experience with different varieties and different weather conditions, it is not so difficult to judge the proper stage of maturity with a fair degree of accuracy.

In the northeastern states where peach orchards are located relatively close to the consumption centers, there is a trend toward picking the fruit at the firm-ripe stage, and using much greater care in packing and handling of the crop. Work at the Illinois Experiment Station has shown that if peaches are harvested when firm-ripe, which is around seven days later than many growers harvest peaches in Illinois and neighboring states, the individual size of the fruit and the total yield can be increased considerably with little or no effect on keeping quality. Fruit picked firm-ripe and held in storage two weeks had good quality and better color and flavor than fruit picked somewhat immature. Such fruit sells easily with little waste. The results indicated that too early picking may result in sufficient loss of cash income to make the difference between operating the orchard at profit or a loss in good seasons.

Peaches are highly perishable and require the most careful handling to prevent cuts and bruises. Picking containers such as the metal one-half-bushel drop-bottom type should be padded and lined with canvas. The pickers must be cautioned beforehand on carefully filling and emptying the picking containers. Temperature is the most important factor affecting the ripening processes. Once peaches are removed from the tree, they must be handled quickly and kept cool or as near to 32° F. as possible until they reach the consumer's table. Trucks and trailers for transporting peaches in the orchard or to the market should be equipped with rubber tires and springs to reduce jolting to a minimum.

The length of the picking season will depend largely upon the temperature during ripening. In most regions where peaches are grown, one can usually depend upon the weather being warm to hot during harvest, and the grower must be prepared to handle the entire crop in the shortest length of time. In normal times, the Elberta ripening season usually covers a period of a week to ten days, but it may be reduced to two or three days during very hot dry weather.

Due to the fact that peach harvest comes relatively early in the season, it is essential to estimate the crop shortly after thinning and order the desired packages immediately.

Yields. Under the present-day system of relatively wide planting distances, liberal fertilization and moderate to light pruning, an average yield of from two and one-half to three and one-half bushels per tree per year may be expected in the East from the standard variety, Elberta. Growers with the better sites and giving good orchard care, however, will exceed this by two to four or more bushels. In the West, regular yields of eight to ten bushels per tree or around 15 tons per acre in good orchards is not uncommon.

Elberta and most peach varieties, bear a small crop the third year in the orchard and a moderate crop at four years with full bearing attained in five or six years. Some varieties, such as Golden Jubilee, however, may bear marketable quantities the third year after planting.

PACKAGING, STORING AND MARKETING

Selecting packages. In the West, peaches for the fresh market are commonly packed in boxes. The size of these boxes is 11½ by 18 inches inside dimensions with a depth which varies from three and one-half to six inches in one-half- and one-quarter-inch intervals. The four and one-half-inch depth is probably the most popular, but the four and one-quarter-

and four and three-quarters-inch depths are also used for the standard packs in which 32 to 96 closely sized fruits are arranged in diagonal or offset rows, two layers deep. The five-inch and deeper boxes are usually three layers deep. There are also one-layer packs but they are uncommon. The reason for variations in depth is because these boxes are standard containers in California for other products such as pears, plums, prunes, persimmons, and tomatoes, as well as for peaches. They are designated as "fruit boxes." So long as the width and length are maintained the same, the use of different depths is not so confusing in storage, loading, and shipping. Lesser amounts of California peaches are packed in four-basket crates of varying depths and some in lug boxes $5\frac{1}{16}$ and 5¾ inches in depth by 13½ by 16⅛ inches, inside dimensions.

East of the Rocky Mountains, the leading çontainers for shipping peaches are one-half and one bushel tub baskets. Also used are six-basket crates and various small sizes of hampers which are locally called peach baskets. The tub baskets may have removable bottoms which permit making the ring face in the first operation. With the development of various ring-packing devices, however, tub baskets without removable bottoms are the most frequently used. The one-half-bushel tub basket is used mainly for the smaller size peaches and for early shipment from the Southeast. Tub baskets are also used in Maryland, Delaware, and New Jersey. Many types of hampers are sometimes used in the East for sale at roadside and neighboring markets. In New Jersey, for example, the 20-quart hamper without a cover is popular for trucking into Philadelphia and near-by markets. The 16-quart hamper is popular in the northeastern states. In New York, the tub baskets are used for shipping and the eight-quart hamper or "high hat" is locally used. In Michigan and Illinois, the straight-side basket and some bushel boxes are used; some fancy fruit is packed in the four-basket flat which holds four three-quart square till baskets. The Western box has received only limited use in the East, although North Carolina and neighboring sections in the Southeast have used it to some extent.

There is a definite trend away from the bushel containers because there is too much bruising and too much weight on the bottom peaches, especially when the fruit has been picked firm-ripe. Experiments in Michigan have shown that the cell-type corrugated container is valuable for shipping and handling firm-ripe peaches. Half-bushel cell-type containers are used holding 96 peaches of from two and one-quarter to two and one-half inches in diameter, weighing from 24 to 25 pounds; 120 peaches of the two- to two and one-quarter-inch size; and 80 peaches of the two and one-half- to two and three-quarters-inch size. The value of these small-type corrugated boxes over the bushel containers in Michigan is pointed out later.

Packing. Where peaches are raised in quantity, packing houses are essential. In the southeastern states, these houses are located in the orchards or near railroad switches in order to reduce hauling. A two-story frame house with the top floor for baskets and other storage space is typical. The lower floor is used for packing and is usually open on at least three sides with a covered driveway. The fruit is delivered at one side and moved across the house during the packing operation, eventually going into railroad cars or trucks at the opposite side.

The same grading and packing equipment used for apples may be used for peaches. However, there are some graders and sizers especially constructed for careful handling of peaches. These machines, in some cases, are provided with wide rubber belts on which the fruit is circulated before the sorters who remove and place it on feed belts according to grade. There are usually two grades. The feed belts then move the fruit to the sizers. Peaches may be sized by size or by weight, but in any event, the machine must be designed to handle the fruit with absolutely no bruising. Peaches may be separated into two to four sizes.

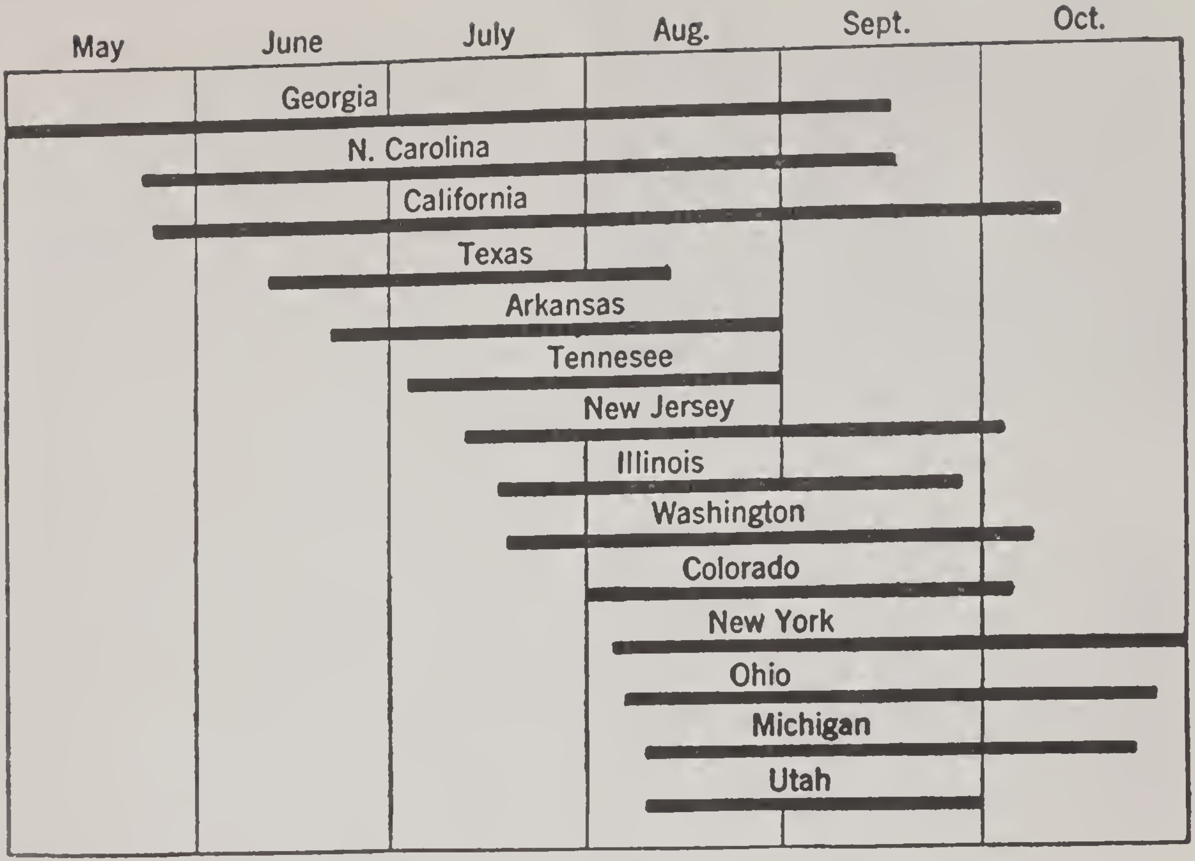
Many of the large peach packing houses use a mechanical peach defuzzer which removes most of the fuzz from the peaches by means of rapidly rotating soft hair brushes. The fuzz is carried by forced draft through ducts to an outside dump. Defuzzing machines are also equipped with a dusting device to coat the defuzzed peaches with sulfur and reduce to a minimum subsequent development of brown rot in storage or shipment. Defuzzers are usually located before the sorting table.

The methods used for packing bushel baskets, consumer packages, and cell-type corrugated boxes are essentially the same for peaches as described for apples in Chapter X. Peaches in most states are packed under the United States grades, specifications for which can be secured from the Production and Marketing Administration, U. S. Department of Agriculture in Washington. Peach growers should follow carefully the Federal specifications or those for their state in order to stabilize the market and provide a uniform and dependable basis for doing business.

STORING PEACHES

Firm-ripe peaches which are not overgrown may be held in cold storage for three to six weeks at a storage temperature of from 30° to 32° F. and 85 per cent humidity. Elberta has been held eight weeks or longer if stored immediately after picking, but this length of time is usually a risk. If peaches are held too long in cold storage, the fruit tends to lose flavor and ripen to such a point that it must be consumed quickly upon removal from storage.

Use of cold storages has been steadily increasing in the northern areas, such as Michigan, for the purpose of holding peaches off the market during periods of oversupply. Storages have also been of value in holding Elberta peaches to supply the market for a few weeks after the general harvest has ended. It must be taken into consideration, however, that this advantage is dissipated in some states where there is a more or less continued supply of fresh peaches coming to the market as the ripening season gradually proceeds from the South to the North.



E. C. Auchter and H. B. Knapp, courtesy of John Wiley and Sons, Inc.

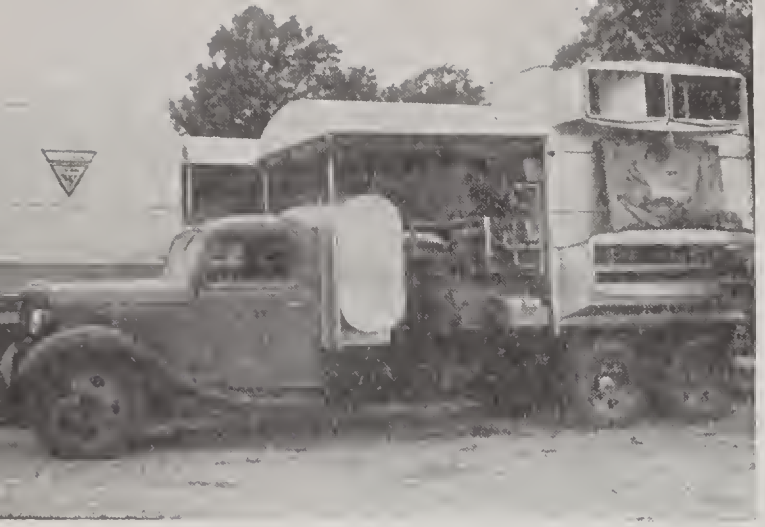
Figure 177. This chart shows carlot shipments by seasons from the various producing sections. Note that competition is severe in normal years between July 15 and October 1. Most of the California crop is canned or dried and, therefore, affords little competition in eastern fresh peach outlets.

SHIPPING PEACHES

As shown in Figure 177, Georgia begins the shipment of peaches to northern markets in May, followed by California, North Carolina, and Texas. The harvest season extends gradually northward until the peaches of Ohio, New York, and Michigan are marketed in September with a few late varieties available in October. Elberta, which is the chief fresh market peach, is available from about the middle of July until late September.

Shipment of peaches for several hundred miles from the southeastern states or from California is largely done by refrigerator car. Shipment of peaches from the big orchards or co-operative packing houses in the heavily populated sections of the East is largely performed by trucks. For example, peaches shipped from co-operative packing houses in Pennsylvania may leave the packing house sometime before midnight and arrive in the New York City market in the early hours of the morning. Shipments of this type during the cool hours of the night and early morning do not require artificial refrigeration.

Where peaches are shipped several hundred miles by refrigerator car, it is essential that the bunkers be kept full of ice to destination, using about 2 per cent salt to reduce the temperature rapidly. Use of electric fans in the cars before or during shipment is valuable in rapidly reducing temperature of the top layers of peaches which otherwise tend to cool very slowly.



H. A. Cardinell, Michigan State College

Figure 178. Portable refrigeration units for precooling fruit in refrigerator cars. By special arrangement in car door, warm air from car is drawn in at top of this unit, circulated over refrigeration coils and exhausted into loaded fruit through duct at base. Due to limited track space, cars are usually allowed to stand for precooling only about 24 hours, which is insufficient time for cooling fruit to 32 degrees F. Cooling is usually to 40 or 50 degrees, but this reduces rate of ripening considerably.

The storage life of peaches may be increased several days by precooling to 30° to 32° F. before shipment; also, quick precooling requires less refrigeration in the long run because there is less time for heat of respiration to develop from the fruit. Precooling of a perishable fruit such as peaches can be done with either portable or stationary mechanical refrigeration equipment. The portable equipment on trucks (Figure 178) is driven alongside refrigeration cars, and by a special system of ducts in the door, air throughout the car is rapidly circulated over the refrigeration coils. In the stationary precooling rooms more time is available for a better job of precooling than with the portable refrigeration on trucks. Thus, fruit loaded into the precooling rooms late in the afternoon at 75° F. requires from 24 to 30 hours to reach 32° F. Opposite walls of the rooms are provided with several windows through which cold air is rapidly moved into and through the fruit stacks. After precooling, peaches are loaded into refrigerated cars kept cool to destination by ice. By precooling, the temperature is reduced at the outset to a level which could hardly be attained by ice and salt after one or two weeks or more in transit. Also, less expense for icing in shipment is needed with precooling.

Floor racks are essential in refrigerator cars to provide air circulation under and between the packages. Containers must be firmly stacked and doors braced securely to prevent shifting in shipment. Once a package gives way or the bulkhead slips out of place, damage may extend through the entire car. The offset system of loading of baskets is best where the weight of the fruit rests on the baskets below rather than more or less directly on the fruit. Peach baskets are usually loaded three tiers high, giving 360 or more baskets per car. Corrugated boxes can be stacked higher. Boxes with bulges should be loaded on their sides. Most railroad companies have complete instructions and diagrams for loading peaches, copies of which can be secured free from the freight stations.

CANNING AND DRYING

Over 90 per cent of the canned peaches originate in California, principally the San Joaquin and Sacramento Valleys. The California fruit growers being far removed from the large fresh fruit markets in the East, discovered early the merits of the clingstone peach for canning and increased this industry to a large scale. Consequently, canning factories in the East more or less dwindled in the face of this severe competition. California produces practically all the dried peaches, except for a small amount from Washington. It also packs about half of the frozen peaches.

In California, the canning trade requests a fruit two and three-eighths inches or more in diameter for Grade 1; it must be firm, ripe, clean, and free from blemishes. Canners accept nothing but No. 1 fruit, except during periods of great demand. When canned, the fruit must be of a pleasing golden color, firm texture, and good quality.

Peaches for drying are picked when fully mature, though still reasonably firm. They are cut around the suture with a sharp knife, the pit removed, and the two halves laid on a clean tray with cut surfaces up. The full trays are treated with sulfur fumes for three to five hours, then exposed to the sun in the drying yard. Drying requires from two to six days until the fruit has a leathery texture. Total drying time varies, but eight days is about an average. The fruit is then cleaned and sorted, and sweated in a storage building to equalize the moisture before delivery to the packer. The drying ratio varies from four to one for some varieties and from eight to one with others. Average yield of dried peaches is about one and one-half tons per acre. In recent years, many yellow canning peaches also have been dried.

In the East, there are several advantages in growing peaches for the canning trade which may tempt the grower to enter the business. However, it should be recognized at the outset that clingstone peaches are strictly confined to the canning trade and that it would be very difficult, if not impossible, to sell any quantity of this type of peach on the fresh fruit market.

QUICK FREEZING

The freezing of peaches is gradually assuming large proportions. In 1945 2,342,000 bushels were frozen in the United States, of which California froze 1,446,000 and Washington, 256,000 bushels. Details for quick freezing fruits are given in Chapter XIX.

MARKETING PEACHES

The greater majority of the peach crop, whether processed or sold fresh, is marketed through co-operative organizations and regular marketing channels as described for apples in Chapter XI. By this system, the grower is relieved of all responsibility after delivering the fruit to the marketing agency. Peaches must be handled fast with little delay. For this reason, some co-operatives in the East send their own representatives or agents to the large wholesale markets during the harvesting and marketing season to check the peaches on arrival and assist in routing them through the wholesale or auction channels. In Michigan, many of the growers with more or less limited acreage, truck their peaches to the Benton Harbor wholesale market for selling direct to buyers. This same system is used in many other states throughout the East.

Retail sales. Because of the perishable nature of peaches, there is often much dissatisfaction among retail chain stores and merchants because of waste due to excessive bruising in handling and shipment, to rotting, and to immature green peaches.

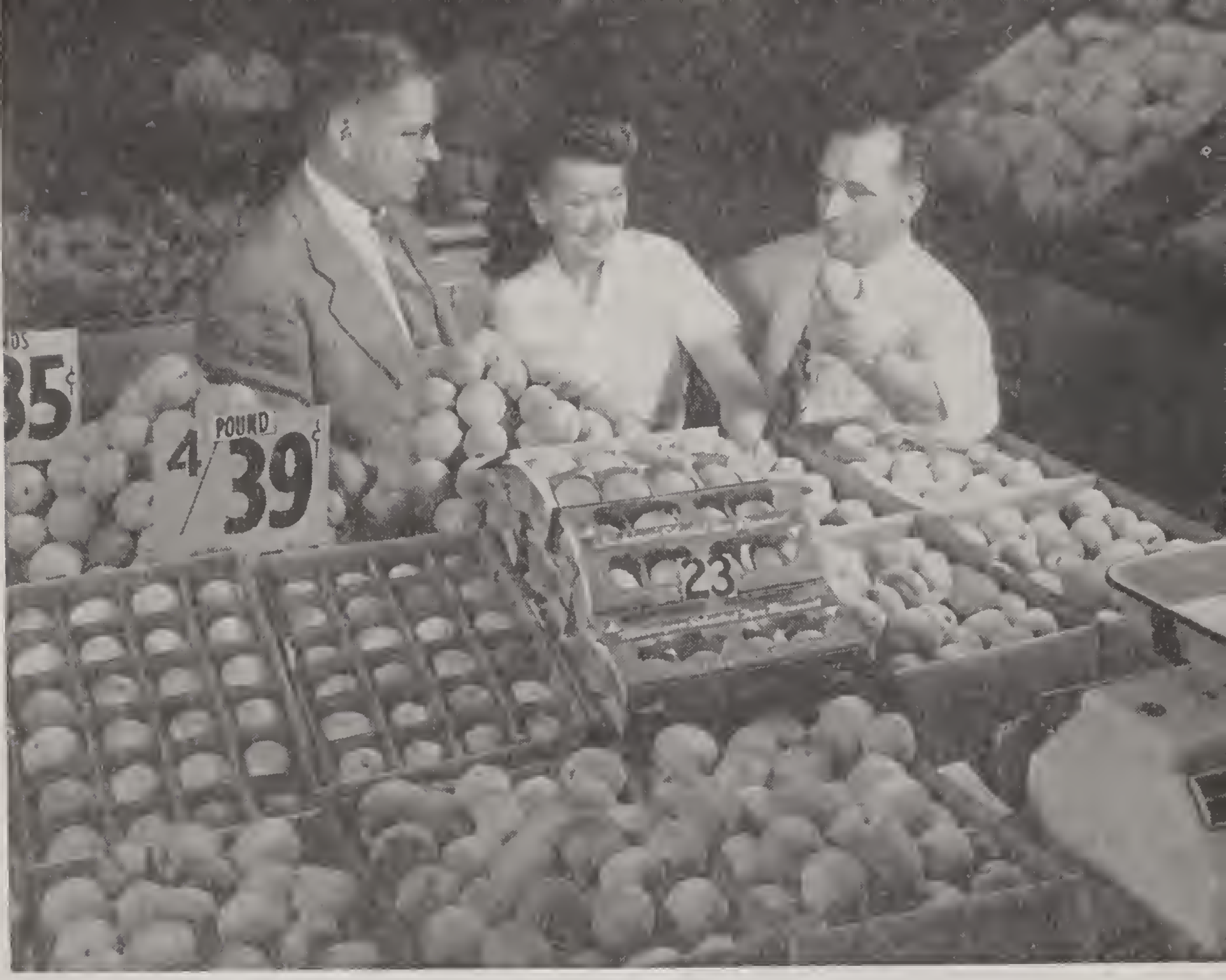
There is considerable difference of opinion in the trade about the proper type of containers for shipping firm-ripe fruit. The Illinois and Michigan Experiment Stations have shown that firm-ripe, well-colored peaches can be satisfactorily handled in shipment and retail stores with little or no bruising, and that they can be sold with much less difficulty at definitely higher prices than the general run of immature green peaches. Merrill's results are typical. He used one-half-bushel cell-type corrugated boxes to protect the firm-ripe peaches in shipment (Figure 179). Several thousand bushels were shipped to distant Michigan markets. The sales of these packages were followed and compared with the typical run of peaches sold in standard bushel baskets on the Michigan markets. There was a decided consumer preference for the fruit picked firm-ripe and shipped in the cell-type boxes. Reasons given by the consumers for buying peaches from these containers were either because of the greater degree of ripeness or the absence of bruises, or both. Bulk and pound sales were made from both the cell-type box and bushel basket. From the cell-type box in Store No. 1, 1368 pounds of fruit were sold in six consecutive days, whereas in the bushel basket, 858 pounds were sold. In Store No. 2, 3781 pounds of fruit were sold from the cell-type box and 1985 pounds from the bushel baskets in 13 consecutive days.

Fruit shipped by bushel basket showed 31.3 per cent bruising, whereas fruit in cell-type boxes showed less than 0.1 per cent bruising. Amount of unsaleable fruit from the bushel baskets due to bruising was 5.4 per cent; in the cell-box, all fruits were saleable.

Cost of packing the box and basket was about the same; four minutes and ten seconds were required for facing, filling, and covering a bushel basket, and about four minutes were necessary for filling and completing two one-half-bushel cell-type corrugated boxes. It is indicated that the cell-type corrugated box when manufactured in large quantities can be purchased for about the same price as baskets of equal size.

FROST DAMAGE AND WINTER INJURY

In California the only injury from cold, which is not frequent, is due to spring frosts during bloom or after the fruit has set. Open blossoms are very tender, but small fruits are more tender, becoming increasingly so until one-half-inch in size. The seed is usually killed, causing the fruit to eventually drop. Blossoms and fruit can be protected by orchard heating, but the grower must decide whether the increased returns brought by saving the crop over a period of years more than offset the cost of heating. If 100 "lard-



Atlantic and Pacific Tea Co.

Figure 179. Peaches harvested firm-ripe are preferred on the market. Cell-type corrugated containers have been suggested as one method for shipping firm-ripe peaches. Entire box can be sold or cell partitions can be removed by layers for pound sales.

pail" type heaters and 600 gallons of oil are used per acre with storage tank, truck tank, buckets, thermometers, and lighting equipment to accommodate the acreage to be heated, the initial cost is calculated at around $100 per acre; thus, annual overhead costs would be about 14 dollars per acre.

East of the Rocky Mountains, the most important factors influencing peach growing are spring frosts and winter injury in one form or another. Winter injury in its broadest aspects is experienced in peach regions above the Mason and Dixon's Line. In South Carolina and neighboring states, the so-called "winter injury" is not so much due to low temperature as to cold March weather following a warm period in February which has induced growth activity. The results of winter injury in a region like Michigan and New York, however, are very clear-cut when a peach crop is lost or when the trees themselves are virtually killed by one extreme drop in temperature. Of almost equal importance to the trees in these regions are the secondary effects of winter injury, including the resultant entrance of peach borers and the canker disease, which together may considerably shorten the life of a tree.

The most common form of winter injury to peaches is the destruction of fruit buds. Leaf buds are usually not injured unless the twigs are killed. It is impossible to give a definite critical temperature for fruit buds of each variety.

The danger point for Elberta during midwinter is usually between −10° and −12° F. and other varieties are compared with it. It will be noted from Table 15, given earlier in this chapter, that fruit buds of Elberta and J. H. Hale are among the most tender in bud; Carmen, Belle, and Golden Jubilee are medium hardy; whereas those of Rochester, Halehaven, and South Haven are among the most hardy to low temperature.

The further the blossoms have opened, the more susceptible they are to cold; peaches in full bloom may be injured at about 25° F., whereas just before the petals open, they may survive 20° to 23° F.

Winter injury is more a factor in weakening peach trees than most growers realize. Injury to roots due to extended periods of low temperature in the North may not appear for one or two years after the damage. Such injury tends to be greater in light sandy soils with no cover crop. Trees in weak condition seem to be the most susceptible to severe winters, whereas those receiving light to moderate applications of nitrogen are more hardy. Trees excessively vigorous, however, are tender.

The following suggestions are given by Johnston for reducing losses from winter injury in Michigan, and, in whole or in part, are applicable to many other states of similar climate.

1. Do not plant commercial peach orchards in areas where the temperature frequently drops below −12° F.
2. The peach site should have a moderately fertile well-drained soil with good elevation above surrounding country (except when near large bodies of water). Exceptionally fertile soils may be hazardous and should receive minimum fertilizer and cultivation.
3. Select varieties which are the most hardy in fruit bud and wood.
4. Perform moderate to light pruning; avoid severe heavy pruning. Where peach canker disease is likely to be a problem, delay pruning until the first of March.
5. Do not apply fertilizers if the foliage has good color and the terminal growth on young trees is about 18 inches, and on old trees about 12 inches. If there is doubt as to how much fertilizer to apply, it is best to apply too little than too much. Peach trees making moderate growth live longer.
6. Start cultivation early in spring and stop early (late June or early July) if the trees are young, or if the mature trees are not carrying a crop. Cultivation may continue for one to one and one-half months longer if the mature trees are carrying a good crop.
7. Under a cultivation system in mature orchards, use a cover crop over winter; in mulched orchards, the mulch provides good root protection.
8. Do not place mounds of dirt around young trees; level the soil about the trunks to prevent water accumulation and ice formation next to the trunk.
9. Thin the fruit of heavily bearing trees to conserve tree vitality.
10. Keep the foliage in a healthy condition by proper spraying. Any insect or disease injury which damages the foliage weakens the trees.

TOP-WORKING AND BRIDGE-GRAFTING

It may be desirable to top-work peaches for the purpose of changing trees which did not come true to name, or, in an unusual case, when a pollinizer variety is needed. Peach varieties are compatible with one another. Top-working is usually done on the younger trees which have an abundance of small pencil-sized branches close to the center of the tree and fairly close to the ground. These branches may be top-worked by budding in late summer and cut back the following spring.

Rodents usually do not injure peaches except during extended periods when the ground is covered with snow. Methods and materials for bridge-grafting are given in Chapter VIII.

COST OF GROWING PEACHES

There are many factors influencing the cost of peach production, but yield per acre is undoubtedly the most important single factor; the higher the yield, the lower the cost of production per bushel. This was clearly shown in California in a cling peach district comprising 653 acres. The orchards were divided into two groups—high and low producing. Average production for the high-producing orchards was 544 bushels per acre; for the low-producing orchards, 342 bushels. Net profit of the high-producing orchards was $98.86 per acre; for the low-producing orchards, $5.99.

The approximate man hours required to do each job in a California peach orchard are given in Table 16. From these data, current costs for doing the various jobs can be calculated on the basis of prevailing wages.

It is apparent that the jobs requiring the most labor in California peach growing are pruning, thinning, and picking. Irrigation, where practiced, ranks fourth in labor required.

During the war year of 1943, cost of growing peaches in Washington averaged $60 per ton, or $474 per acre, based on the records of 69 representative producers in an average-crop year. High production per acre was closely associated with low-production costs per ton. Thus, cost per ton of producing peaches with yields less than four tons per acre average $89; with yields of from four to seven tons, $71; seven to ten, $59; ten to thirteen, $52; and thirteen tons or more, slightly less than $52. Labor costs, including supervision and operators' management, amounted to 70 per cent of the total cost. Labor before harvest was paid 75 cents per hour, while harvest labor was paid 80 cents to over $1.00 per hour, hired on an hourly basis.

In Michigan during the high-price labor year of 1943, the average cost per acre of producing peaches on 88 representative farms, including overhead costs, was $162.41, or $2.20 per bushel (orchard run) on the basis of 74 bushels per acre. This was a low-crop year for these orchards and it was suggested that Michigan growers should average 150 to 200 bushels per acre if they expect to make much money. From 1920 to 1941, Michigan peach prices were

TABLE 16

Estimated Labor Requirements per Acre for Full-Bearing Cling Peaches in California[1]

Operation	Hours per Acre		
	Man	Truck	Tractor
Pruning	45.0	...	...
Brush disposal	4.0	...	1.3
Planting covercrops	1.0	...	...
Fertilizing	2.0	0.7	...
Fall spray	4.5	...	1.5
Early spring spray	4.5	...	1.5
May arsenate of lead spray	4.5	...	1.5
Checking, 3 times	1.5	...	1.5
Irrigation, 5 times	20.0	...	...
Cultivation, 6 times, one way	5.0	...	...
Miscellaneous	4.0	0.5	...
Subtotal	96.0	1.2	12.3
Thinning	90.0	...	...
Bracing and propping	3.0	1.0	...
Picking 10 tons	100.0	...	...
Hauling 10 tons	8.0	8.0	...
Total	297.0	11.4	12.3

[1] Data from: Klamt, R. H., and A. Shultis. Cling peach cost and efficiency study, Sutter County. 1933. Published by the California Agricultural Extension Service. These hours may be reduced by using the newer labor-saving machinery.

on a gradual downward trend due to a gradual increase in production. Although prices were high during and after World War II, it was indicated that future prices might be less than the 1920–44 average of $1.06 a bushel.

In Table 17, figures for the cost of production per acre and per bushel of peaches in New Jersey are given. Figures were obtained during the depression year of 1931 and are based on an average of 20 farms with an average yield of 215 bushels per acre, involving 338.5 acres of bearing trees. It is apparent that the largest cost for materials in growing peaches in New Jersey is for containers, with spray materials ranking second, and fertilizers third.

NECTARINES

Peaches and nectarines are quite similar in appearance of the trees, growth responses, bearing habits, and other general characteristics. The chief difference is that peaches have a fuzzy skin, while nectarines are fuzzless and smooth. Also, nectarines are usually smaller in size, have greater aroma, are in general less melting in flesh, less suited for shipment to distant markets, and because of lack of fuzz are more susceptible to curculio and thrip damage. Nectarines can be grown in almost all regions where peaches are grown, but in humid areas they are more susceptible to brown rot. There are some regions in California, however, where it is practically impossible to grow

TABLE 17

Cost of Producing Peaches in New Jersey 1931[1]

Average of 20 farms with a total of 338.5 bearing acres
Average yield 215 bu. per acre

	Cost per Acre	Cost per Bushel	Per Cent of Total Cost
Cost up to harvest			
Fertilizer 319 lbs. per acre	$ 5.31	$0.025	$ 4.65
Cover crop	.64	.003	.56
Spray material	9.68	.045	8.48
Man labor 46 hrs. per acre	12.21	.057	10.70
Horse labor 7 hrs. per acre	1.33	.006	1.17
Machine use 4 hrs. per acre	.27	.001	.24
Tractor use 6 hrs. per acre	4.25	.020	2.72
Miscellaneous	8.26	.038	7.24
Total cost until harvest	$ 41.95	$0.195	$ 36.76
Harvesting cost			
Man labor 79 hrs. per acre	$ 20.52	$0.095	$ 17.98
Horse labor 7 hrs. per acre	1.23	.006	1.08
Machine use 7 hrs. per acre	.49	.002	.43
Tractor use 15 hrs. per acre	.14	.001	.12
Truck use	.53	.003	.46
Containers	25.18	.117	22.07
Miscellaneous	.73	.003	.64
Total harvesting cost	$ 48.82	$0.227	$ 42.78
Overhead			
Interest on orchard investment at 5%	$ 8.91	$0.041	$ 7.81
Depreciation of machinery and equipment	2.57	.012	2.25
Taxes	5.06	.023	4.43
Interest on costs at 2%	1.20	.006	1.05
Total overhead costs	$ 17.74	$0.082	$ 15.54
Total production and harvesting costs	$108.51	$0.504	$ 95.08
Marketing costs			
Man labor 5 hrs. per acre	$ 1.22	$0.006	$ 1.07
Truck use 34 mi. per acre	3.08	.014	2.70
Ferry	.41	.002	.36
Cold storage	.90	.004	.79
Total marketing costs	$ 5.61	$0.026	$ 4.92
Total prod., harv., and mark. costs	$114.12	$0.530	$100.00

[1] Compiled from: Waller, A. G., and Carncross, J. W., 1933, Facts on fruit and vegetable farming in New Jersey, 1926–1931. N. J. Agr. Exp. Sta. Bull. 555.

nectarines because of the grain thrip damage to pollen and pistils, causing either no set or badly scarred fruit.

Origin of the nectarine is unknown, but its history goes back for 2000 years and merges into that of the peach. Genetically, the nectarine is an interesting phenomenon in horticulture. Peach trees may develop from nectarine seeds, and nectarine trees from peach seeds, or, peach trees may develop nectarines by bud sports and nectarine trees may develop peaches in a similar manner.

California is the largest commercial producer of nectarines, particularly in the upper Sacramento Valley where large quantities of nectarines are shipped to the Eastern markets, consisting especially of the Queta variety. California has practically all of the 257,000 nectarine trees in the United States, except for about 500 trees in Texas (U. S. Census for 1940).

The Stanwyck variety is the best known; Queta and Gold Mine are promising new varieties. The Gower variety is fairly well known, medium-sized, highly colored, white-flesh, and of the freestone type. Varieties of nectarines in the order of ripening are Cardinal, Early Rivers, Dixie, Lord Matier, New White, New Zealand seedlings (Ansenne, Diamond Jubilee, Gold Mine, Muir's seedling, New Boy, Sure Crop), Lippiatt's Late Orange Gower, Humboldt, Queta, Stanwyck, and Spanish.

For recommendations on the culture of nectarines, the reader is referred to the previous discussion on peaches, since, in general, cultural practices for nectarines are the same as for the peach.

Harvesting and handling nectarines. Nectarines are shipped primarily for dessert purposes. A few nectarines are dried commercially, but none are commercially canned because the varieties now grown are not well adapted to canning. Gower and the New Zealand seedlings are outstanding for home canning, but being tender, they tend to fall apart more than peach varieties adapted to canning.

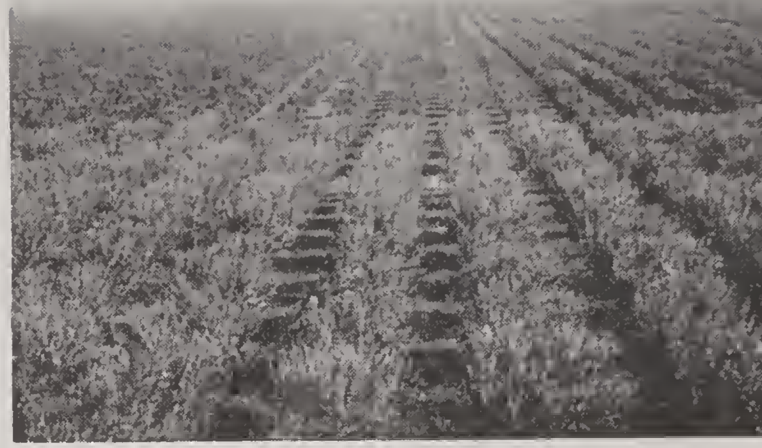
For distant shipment, nectarines are packed in the standard California peach box, using egg case dividers, and separated by cardboard layers. Fruit sold locally is generally unpacked in various size lug boxes.

APRICOTS

The apricot probably came from western China while certain hardy strains known as Russian apricots came from Siberia. The apricot was brought to Rome about the time of Christ. Apricots were grown in Virginia as early as 1720. The commercial culture of this fruit is now limited to the semiarid irrigated districts on the Pacific slope (Figure 180). In 1945 there were 5,641,625 trees in the United States, five-sixths of which were in California. The ten-year average production from 1937-46 was 239,685 tons of which California produced about 92 per cent, Washington about 6 per cent, and Utah about 2 per cent. A record crop of 351,800 tons was grown in 1944. Since 1934, fresh sales of apricots have averaged about 13 per cent of production, canned about 27 per cent, dried 56 per cent, and for other uses including home use and freezing, about 4 per cent. Freezing of apricots was negligible prior to 1942, but in 1944, almost 23,000 tons or 6 per cent of the crop was frozen.

The most important varieties in California are Blenheim, Royal, and Tilton; in Washington, the large Early Montgamet, Moor Park, and Wenatchee

Moorpark are grown; the Large Early Montgamet is the leading variety in Utah. Kernels of some varieties of apricots such as the Early Montgamet are almost as pleasant in flavor as almond kernels. All apricot varieties grown commercially in America are self-fruitful.



F. P. Cullinan, U.S.D.A.

Figure 180. Apricots and peaches constitute important industries in California. Rows in this orchard are three miles long, with apricot trees in the foreground and peach trees in the background.

The open flowers of the apricot are about as resistant to spring frosts as the peach, but they are more likely to be killed because they tend to open earlier. Apricot fruits are very susceptible to the brown rot disease and, therefore, commercial growing is limited to those sections where the springs and early summers are not humid. Also, apricots must be grown in sections where there is little danger of spring frosts or of severe winter freezes after warm spells.

The total commercial crop of apricots tends to vary more in California from year to year than the peach crop, largely because the flowers and young fruits are very susceptible to brown and green rot in those regions where the blossoms are not killed by frost.

Rootstocks for commercial apricot plantings consist largely of peach and apricot seedling roots. Apricot roots seem to be better in sandy soils because of greater resistance to nematodes, although there are now available some nematode resistant peach stocks which are often used. Myrobalan plum rootstocks are frequently used for apricot trees grown on the heavier more impervious soils.

Fruit thinning and pruning. Apricot fruits develop rapidly and ripen early in summer. Like the peach, the fruits have a period of retarded growth about the time the pit is hardening. The trees blossom and set fruit heavily, resulting in small size of the fruit at harvest. The practice of fruit thinning does not increase the size of apricot fruits to the extent that it does with the peach or plum fruits. Hence, pruning to reduce the number of flower buds is the most important means of increasing fruit size.

The apricot tree tends to develop large heavy branches, more so than the peach. Therefore, the modified-leader system of training, as described for apples in Chapter IV, appears advisable, although the vase-form tree has proven satisfactory in most areas. Mature apricot trees are pruned somewhat less than peach trees, although more than the apple. The fruit is borne on short one-year spurs and largely toward the tip of last year's shoot growth. After the branch containing these spurs has borne fruit for about three years,

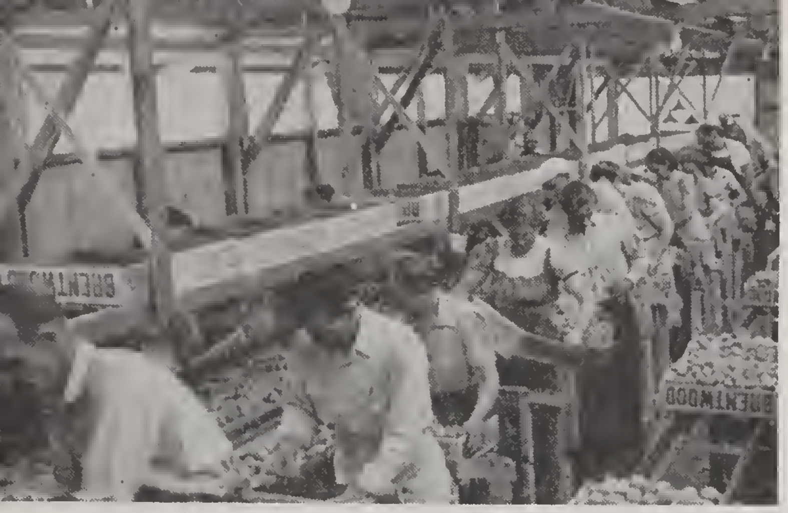

A. J. Schoendorf, California Fruit Exchange, Sacramento

Figure 181. Packing fresh apricots in California, showing empty box supply at top left; moving fruit supply belt below; the packers and the conveying equipment at right.

they tend to die and the object of the pruning is to induce new growth in these areas for subsequent fruit production. For young trees, pruning should be moderate to light and only sufficient for properly training the tree; for mature trees, it should be directed mainly at maintaining the proper height and width spread. Heavy pruning delays bearing and reduces yield.

Cultural systems for the apricot are similar to those for the peach, except that apricot trees appear to require somewhat less nitrogen. There is also some evidence to indicate that they will grow and produce with a lower supply of potassium.

ALMONDS

The almond probably came from western Asia, and was brought to Greece and North Africa in prehistoric times. Its culture in North America is limited to California where there are slightly more than 100,000 acres of almond trees. Average ten-year production between 1936–45 in California was 17,470 tons. This figure rose to 37,800 in 1946.

The California varieties are from local seedlings of strains brought from southern Europe and northern Africa. The most extensively grown variety is the Nonpareil. Other varieties are IXL, Drake, Texas, and Ne Plus Ultra, Peerless, and Eureka. Jordonalla and Harpareil are promising new varieties developed by the U. S. Department of Agriculture co-operating with the University of California.

Climatic adaptations. Commercial almond growing in California is limited to those areas where there is little or no frost hazard, due, in part, to an early blossoming characteristic of the almond. The almond is also susceptible to injury by rainy weather in spring and summer which increases blossom and fruit infection by brown and green rot organisms; rains in midwinter are apt to cause infection by a shot-hole disease, while foggy and rainy weather during the summer results in brown stains on the shells of the ripening nuts, lowering their market value.

Pollination. Important almond varieties in America are self-sterile; some are cross-incompatible. Pollination is almost entirely by insect activity, and in view of the fact that almonds blossom early while the weather is likely to be too cool for insect activity, it is necessary to closely interplant pollinizing varieties. In some orchards, every tree is adjacent to a pollinizing variety, whereas in other orchards, blocks of one variety may be five rows wide if the rows are no farther apart than 25 feet. Differences in time of blossoming tend to be wide among almond varieties. Therefore, the orchard should consist of more than two varieties, preferably three or four. Nonpareil, Ne Plus Ultra, and Texas are often interplanted for cross-pollination. If Texas is planted in numbers larger than one row in seven, it may be advisable to interplant with one adjacent row of a fourth variety, Drake, to supply pollen for the late opening Texas flowers. The pairs, IXL and Nonpareil, and Jordonalla and Harpareil, are cross-incompatible; with either pair, it is necessary to use a third variety such as Peerless which blossoms in midseason.

Rootstocks. Almond trees grow best on almond roots. According to experienced growers, bitter almond stocks are slightly better than the sweet almond stocks. Almond trees on peach roots have been shorter-lived in California, especially on soils high in lime and sodium. Peach roots resistant to nematodes are often used for almond stocks on sandy soils where nematodes tend to be a problem. Almond trees do not make good graft unions on apricot and Myrobalan plum rootstocks.

Cultural requirements. Almond orchards produce best on the lighter sandy types of soils. Although the almond is more resistant to dry soils than most other orchard trees, it shows definite response to summer rainfall and irrigation on shallow soils. The almond has a high nitrogen requirement similar to the peach. However, it will tolerate a lower available potassium content of the soil than prunes and apples and its zinc requirement seems to be somewhat lower than most other fruits in California. The soil management program for the almond is similar to that of the peach in California.

Pruning. In general, almond trees are pruned lighter than peach trees, because more fruiting wood is necessary for a crop, and because almond growing is usually on a more narrow margin of profit. Most growers prune every second or third year only, because the benefits of pruning every year are usually not great enough to pay for the extra labor. Due to lighter pruning, almond trees tend to become large with long branches which may be very heavily loaded. For this reason, a modified-leader system of training seems best. Larger and fewer cuts are made on almond trees as compared with peaches. Cuts are made where the wood is three-quarters to one and one-half inches in diameter near a strong outward-growing lateral branch.

Yields and harvesting. Almond trees will bear some nuts the third or fourth year in the orchard, and by the eighth year will yield as much as 1000 pounds of nuts per acre. Yields of 2000 to 3000 pounds per acre are occasionally reported, but this is unusual. Fruit thinning is not practiced with almonds.

Harvesting starts when almonds in the shady portions of the tree show shriveling and cracking open of the hulls. Sheets of canvas are spread on the ground and limbs jarred with padded clubs. The nuts are taken immediately to the hulling machine for the removal of the hulls. Pieces of hull which adhere to the shells after passing through the machine are removed by hand where possible. Those nuts on which the hulls stick tightly, however, are sent to the cracking machine for removal of the kernels. The kernels are dried in the sun in shallow bins or in bags, until they can be broken without bending. Next, the kernels are bleached in sulfur fumes to retain their yellow color in the shell, after which they are graded and stored in a cool dry place to avoid becoming rancid. Properly dried nuts should keep in such a place for more than a year. A large part of the crop is now shelled and the kernels are dried in the shade to prevent them from turning dark.

A small portion of the crop in California is harvested in early June at the time when the embryos first fill the seed coat. These more or less green kernels are shipped to New York City where there is a special demand from people from foreign countries who have been accustomed to eating the kernels so-prepared.

Review Questions

1. Briefly compare peach production in California and in the eastern states.
2. What are the 5 leading states in peach production; what is the approximate annual production of peaches in the United States?
3. Describe a good soil management program for young peach trees growing in a moderately fertile sandy loam soil.
4. Give a good soil management program for mature bearing peach trees growing in a moderately fertile medium-loam soil in your locality.
5. What system of training is usually employed for peach trees? Describe how the newly planted yearling peach tree is pruned.
6. What is meant by the "renewal system" of pruning bearing peach trees, and what is its purpose?
7. Describe a fertilization program for a bearing peach orchard which is making 6 to 8 inches of thin terminal growth under a system of clean cultivation with a non-legume cover crop. The soil is moderate to low in fertility.
8. Prepare an orchard planting plan for a 10-acre peach orchard located on a 10 per cent slope within a few miles of a large city. Disposal of the crop will be through a roadside market and trucking to neighboring markets.
9. When is the proper time for picking peaches for (1) local sale, (2) truck shipment to large cities within a distance of 200 miles, and (3) shipment by railway several hundred miles?
10. When is the proper time to thin peaches; how much thinning should be done on a full-bearing early-maturing peach tree carrying a moderately heavy crop?
11. At what temperature and humidity should Elberta peaches be stored?
12. How long can peaches be stored?
13. According to experiments in Michigan and Illinois, what type of peach does the customer prefer to buy in pound lots?
14. What jobs in peach growing require the most labor; what items are largest in cost of materials?
15. Give 5 important precautions against winter injury to peach fruit buds.
16. How does a nectarine differ from a peach?
17. Describe how apricot fruits are thinned.
18. What are the climatic requirements for almonds?

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CHAPTER XV

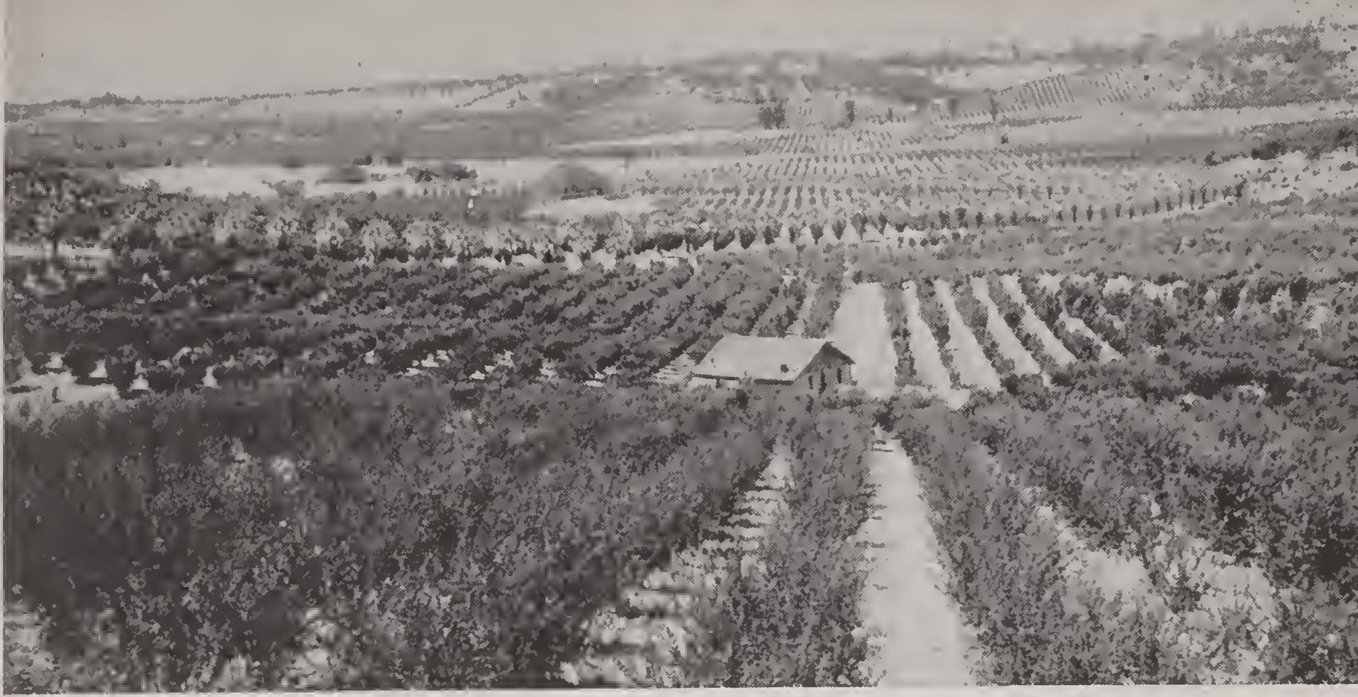
Culture of Plums

Plums are more widely adapted in the United States than almost any other deciduous fruit. This is because there are many species and varieties which are adapted to one or another of the different climatic and soil conditions. Plums will thrive where winters are cold and the summers hot, or where it is dry or the rainfall is heavy. For home use, they are suitable for most orchards throughout the temperate zone. But, commercially, their production is restricted to rather definite areas on the Pacific coast (Figure 182).

In Europe, it is a question if plums rank first or second in importance among the deciduous tree fruits, whereas in the United States they are exceeded by apple, peach, and pear. The European type of plums reach their highest development in the world on the Pacific coast in California, Washington, and Oregon. Plums in this region are relatively free from attacks of curculio and black knot which are quite troublesome in eastern orchards.

Figure 183 shows the distribution of plum trees in the United States. According to the U. S. Census of 1945, over 80 per cent of the trees were in the Pacific coast states. California had 13,894,006 trees; Oregon, 3,099,191; and Washington, 802,367. Rather limited areas of plum trees which produce fruit for local near-by markets are found in Texas and the states south and east of the Great Lakes. Most of the trees in these areas are noncommercial. Between 1930 and 1940, there was about a 25 per cent reduction in both bearing and nonbearing plum trees in the United States. In 1940, California had 1,192,000 nonbearing trees, or about one-third of the national total; almost half of these were in Santa Clara County, a heavy prune-producing area. In 1945, Texas had 552,863 trees; New York, 433,021 trees, and Michigan, 363,488 trees.

During the full-crop year of 1939, 93 per cent of the total United States crop of plums and prunes was produced in California, Michigan, Washing-



California Fruit Exchange, Sacramento

Figure 182. One of the largest centers of plum production in California is in the Sierra foothills. This district has developed because fruit ripens early, and there are good irrigation and transportation facilities. Trees are planted closer because soil is relatively shallow.

ton, Oregon, and Idaho. Prunes are produced in greater quantities than plums.[1] The four leading states in prune production are California, Washington, Oregon, and Idaho. The ten-year average from 1937–46 for these four states was 594,390 tons, over three-fourths of which were raised in California. Practically the entire prune crop in California is dried. The same is true for western Washington and Oregon. In eastern Washington and Oregon, however, most of the crop has been canned or sold fresh, with recent increases in canning and freezing. Most of the Idaho prune crop has been sold fresh.

Almost the entire commercial crop of plums is produced in California and Michigan. For the ten-year average of 1937–46, California produced an average of 75,100 tons of plums and Michigan, 4,290 tons. Nearly all of the plums raised in California and Michigan are sold fresh.

GROUPS OF PLUMS

Over 2000 varieties of plums have been grown in the United States, consisting of about 15 species. Very few of these species, however, are commercially important; namely, *Prunus domestica* (European plums), *Prunus salicina* (Japanese plums), and hybrids of the latter.

European type. This is the most important group in the United States. The plum is characterized by a large strong vigorous tree with large thick leaves which are glossy dark green above and pale green with considerable pubescence beneath; the leaf edges are coarsely notched or sawtoothed. The

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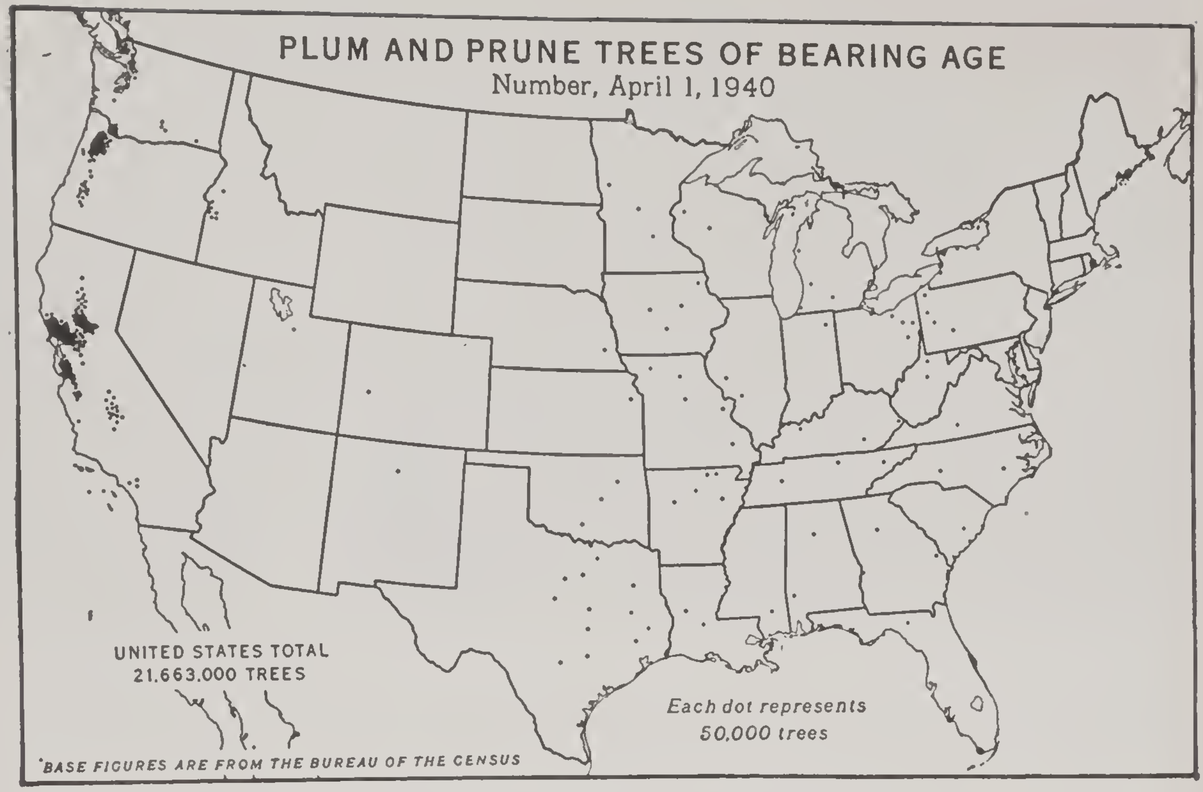
[1] A prune is a plum which because of higher sugar content can be dried whole without fermentation at the pit. Growers in California who ship their fruit to canneries are known as plum growers, while those producing drying varieties are known as prune growers. Commercially, the prune is largely dried, but it is also canned and sold fresh. Plums are sold fresh, canned, or split and dried with the pit removed.



U.S.D.A. Bureau of Agricultural Economics

Figure 183. Distribution of bearing plum and prune trees in the United States according to the 1940 Census. Commercial plum and prune growing is largely confined to the West Coast where over 80 per cent of the trees are located, and over 90 per cent of the crop is produced.

fruit is borne largely on spurs, is variable in size, color, and shape, and the stone either clings to or separates from the flesh. Due to the rather wide variation of color, shape, and flesh characteristics of the fruit, the European plums have been divided into the following subgroups:

(*A*) *Prune group* is usually distinguished from the other European plums because they can be successfully dried without removal of the pit. It includes such popular varieties as French, Sugar, Italian, German, Imperial Epineuse, and all varieties of plums grown for drying.

(*B*) *Reine Claude group* is characterized by more or less round fruit which has a very slight suture and of green, yellow, or slight red color. The flesh is sweet, tender, and juicy. Varieties include Reine Claude, Jefferson, and Washington which are important among canning varieties.

(*C*) *Yellow Egg group* is a comparatively small and relatively unimportant group which is desirable for canning only. Best known variety is Yellow Egg.

(*D*) *Imperatrice group* is a large group, including practically all of the blue plums. Chief fruit characteristics are blue, heavy bloom,[1] medium-size, oval shape, firm flesh, and thick skin with only fair quality. Important varieties include Grand Duke, Diamond, Tragedy, and President.

(*E*) *Lombard group* is similar to the above group, except that the fruits are red in color instead of blue, probably of smaller size, and of somewhat lower quality. Varieties include Lombard, Bradshaw, and Pond.

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[1] This refers to powdery film over skin, not to blossoming.

Japanese type. In California, the Japanese type of plum comprises the larger number of shipping varieties. The trees are early blooming and susceptible to frost. Many of the varieties are about as hardy to winter cold as the peach and can be grown under a wide range of conditions. Fruit of the Japanese varieties is easily distinguished from the other types of plums by its large size, heart shape, often with a pronounced apex, and its bright yellow or red color. Fruits of Japanese varieties are never blue. Flesh is yellow or red, juicy, and firm; the dessert quality ranges from fair to excellent, depending upon the variety. There is considerable variation in character of tree growth, with some varieties being low and spreading in habit while others grow definitely upright. They somewhat resemble the peach in their general growth habit, color, and type of bark. Leaves are medium-sized, and sharp-pointed and are free from hair on the lower surface in comparison with the European sorts which are hairy on the lower surface. The Japanese sorts are distinguished also by their early and very abundant flowers which are produced three in a bud on either new wood or spurs.

Other plum types. In addition to the above more important types of plums, the following are worthy of mention because: (1) They are often found in home orchards; (2) They may be of value as rootstocks for commercial varieties; or (3) They have desirable characteristics for hybridizing.

The *Myrobalan* or cherry plum (*Prunus cerasifera*) is widely used as a rootstock for European and Japanese varieties of plums because the tree is hardy and vigorous. Fruit of the Myrobalan tree is small, round or oval, yellow or red in color, and with a rather insipid flesh. Chief value of the fruit is the seed from which the seedling rootstocks are grown.

The *Simon type* (*Prunus simoni*) is somewhat similar to the apricot in shape and color and, therefore, is often called the apricot plum. Its chief value is for crossing with Japanese types, giving such common varieties as Climax and Wickson.

Damson plums (*Prunus insititia*) are occasionally found in home orchards where the fruit is limited to culinary purposes because of its small size and sour or acid flavor. Trees are very hardy, productive, relatively free from diseases, require little care, and are produced from seed rather than by budding or grafting.

CHOICE OF VARIETIES

The geographical region and varieties of plums selected will depend upon the proposed market outlet. If the western grower intends to ship a large portion of his crop on a fresh basis, it is important that he plant not more than six or eight varieties of well-known shipping quality. Practically all miscellaneous sorts should be eliminated. The eastern market is interested in obtaining large quantities of relatively few varieties, and not limited amounts of a large number of varieties. Many small shipments of from 10 to 20 boxes are undesirable and discriminated against by most eastern buyers. In California, the early and late varieties give greater promise of satisfactory returns than most of the midseason sorts.

The following varieties are grown commercially for shipping in California and are listed for the most part according to ripening from June to September: Beauty, *Tragedy,*[1] Formosa, Climax, California Blue, Burbank, *Santa Rosa,* Duarte, *Wickson,* Diamond, *Kelsey,* Satsuma, Gaviota, Giant, Grand Duke, Pond, and *President.* Santa Rosa is increasing in popularity as a shipping plum and made up nearly 50 per cent of the nonbearing trees in 1946. The following varieties are used primarily for canning: Jefferson, Reine Claude, Washington, and Yellow Egg. The canning trade desires the large, firm, green or yellow plums. Large plums which are not smaller than 12 to a pound bring a premium as first-grade canning stock; plums not smaller than 20 to a pound are rated second class for canning.

Due to high prices received for early fresh fruit from California, importance of the plum variety is determined as much by its earliness as by any other factor. This is not true in the Pacific Northwest states where little or no premium exists for earliness, because early varieties compete with California midseason varieties. In general, California meets only limited competition from plums grown in other states. However, the early varieties meet considerable competition in the eastern markets with Georgia peaches, and the midseason and later varieties come into competition with California Bartlett pears and with shipping prunes from the Pacific Northwest.

The Italian Prune or Fellenberg is the only important variety grown in the Pacific Northwest where it reaches high quality not only for fresh shipment but for drying and canning. As stated above, it gives strong competition to later California varieties which are shipped fresh. Italian Prune is the only important fresh-type plum which is canned in the West.

For drying, the French Prune (Prune D'Agen) accounts for over 80 per cent of the California acreage. Other important drying varieties are Imperial, Sugar, and Robe de Sergeant. Varieties for drying are grown mainly near the Pacific Coast where summer temperatures are lower, favoring high quality of the dried product. Important regions are next to San Francisco Bay in California, in the Willamette Valley of Oregon, and in Clark County of Washington.

If the plums are to be sold at the roadside market or at local stores, which is the usual marketing procedure for eastern growers, it is desirable to have a number of varieties ripening over several weeks in order to keep a continual supply of fruit on the counters. In the East, the only varieties grown commercially and usually on a relatively small scale are Italian Prune and Stanley. Other varieties suggested by Wellington of the New York Experiment Station for trial for roadside market and local trade are, in the order of ripening: Early Laxton, Beauty, Formosa, Santa Rosa, California Blue, Clyman, Oullins, Utility, Washington, Prinlew, Yakima, Hall, Reine Claude, Albion, and

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[1] Most important varieties are in italics.

French or Shropshire Damsons. Varieties recommended for home and market in Texas are America, Compass Cherry, Gold, Munson, Omaha, and Opata. Popular varieties in Missouri are Munson, Red June, Gold, Wild Goose, Green Gage, Shropshire Damson, Lombard, Omaha, French Damson, President, German Prune, and Italian Prune.

POLLINATION

European plums. European varieties of plums fall into either one of two groups, self-fruitful or self-unfruitful. It has been shown that about 30 per cent of the flowers will set fruit on self-fruitful varieties whether the flowers are cross- or self-pollinated; this is considered more than a sufficient set for a commercial crop. Flowers of the self-unfruitful varieties, however, set only about 1.5 per cent; this is insufficient for a commercial crop, necessitating interplanting with pollinizing varieties.

Among the self-fruitful varieties are the following: Agen, Bavay, California Blue, Coates 1418, Czar, Drap D'Or, Early Mirabelle, French Damson, German Prune, Giant, Goliath, King of the Damsons, Monarch, Ontario, Ouillins, Pershore, Purple Pershore, Sannois, Shropshire Damson, Stanley, Sugar, Victoria, and Yellow Egg.

Among the self-unfruitful varieties are: Altham, Allgrove's Superb, Anita, Arch Duke, Belgian Purple, Blue Rock, Bradshaw, Burton, Cambridge Gage, Clyman, Coe's Violet, Conquest, Crimson Drop, De Monfort, Diamond, Esperen, Frogmore Damson, Golden Drop, Grand Duke, Hall, Hand, Italian Prune,[1] Imperial, Imperial Epineuse, Imperial Gage, Jefferson, Late Orange, Late Orleans, Miller Superb, McLaughlin, Pond, President, Quackenboss, Reine Claude, Rivers' Early, Rivers' Early Prolific, Sergeant, Silver, Standard, Sultan, Tragedy, Transparent, and Washington.

Due to the fact that some of the above self-fruitful varieties apparently have different strains in different regions, it is probably safer to interplant with at least one pollinizing variety. The varieties which tend to be variable include Italian Prune, Agen, Reine Claude, and German Prune, which may be self-fruitful in some regions and self-unfruitful in others. All varieties listed above in both groups, except for the variety, Esperen, have good pollen for cross-pollination, provided the blooming seasons overlap sufficiently. There are some combinations, however, which are cross-unfruitful because of close relationship. These include Golden Drop, Coe's Violet, and Allgrove's Superb. Another cross-incompatible group is Cambridge Gage, Late Orange, and President.

The European plums in the East usually overlap sufficiently in blooming periods to provide adequate cross-pollination. In some localities, however, Italian Prune and Imperial Epineuse may bloom too late for adequate cross-pollination by such early-blooming varieties as Reine Claude, Lombard, or

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[1] Italian prune is self-fruitful in the Pacific Northwest.

Grand Duke. In this case, another late-blooming or midseason-blooming variety should provide cross-pollination for the late-blooming varieties.

European varieties grown in California, with the exception of Tragedy, fall into rather distinct groups with relation to season of blooming. Midseason-blooming varieties are Agen, Clyman, Grand Duke, Diamond, Quackenboss, Jefferson, Standard, Sugar, Imperial, and President. Late-blooming varieties are California Blue, Hungarian, Pond, Giant, Italian Prune, Yellow Egg, and Washington. In normal seasons, those varieties blooming after President are not effectively cross-pollinated by varieties of the early group. Tragedy, however, having a long blooming period, usually blooms along with several of the late-blooming Japanese varieties and extends into the blooming period of Grand Duke and Diamond.

Japanese plums. Most of the varieties in the Japanese group are self-unfruitful. These include Abundance, America, Apex, Apple, Burbank, Combination, Duarte, Eldorado, Formosa, Gaviota, Kelsey, Prize, Red June, Satsuma, Upright, and Wickson.

Although Beauty, Climax, Methley, and Santa Rosa produce more fruits from self-pollination than other Japanese plums, it is recommended that they also be interplanted with pollinizers. The following varieties are not recommended for pollinizers because their pollen tends to be low in viability: Apex, Apple, Combination, Eldorado, Formosa, Gaviota, and Kelsey. Shiro is doubtful and probably should be placed also in this classification. Varieties which are considered somewhat more dependable as pollinizers are Abundance, Burbank, Duarte, Elephant Heart, Methley, Monitor, Santa Rosa, and Wickson, although they, too, may show some to considerable sterility.

European and native plum varieties as cross-pollinizers. European plum varieties are not consistently effective in pollinizing Japanese plum varieties. Fair to good sets on Japanese varieties have been obtained by cross-pollination from Clyman, Ouillins, Reine Claude, Victoria, and Yellow Egg. Tragedy is fairly effective for cross-pollination of Japanese varieties, but the reciprocal relationship is unfruitful. American species of plums (see below) which possess viable pollen have been found to be most effective as pollinizers for Japanese varieties.

American species and hybrid plums. The following varieties of the American species are self-unfruitful: *Prunus Americana:* De Sota, Hawkeye, Rollingstone, Wyant Var. Mollis, and Wolfe; *Prunus hortulana:* Wayland Var. mineri, Miner, and Surprise; *Prunus munsoniana:* Wild Goose and Newman; and *Prunus nigra:* Cheney. Some hybrids between American and Japanese species are self-unfruitful largely because of nonviable pollen; they include Red Wing, Monitor, Underwood, Elliott, La Crescent, Tonka, Radisson, and Fiebing; these varieties are obviously of no value as pollinizing varieties. The following varieties can be used for pollinizers, although they, too, contain considerable nonviable pollen: Assiniboin, Cheney, De Sota, Newman, Miner, Surprise, Rollingstone, Wyant, and Wolfe. The Surprise variety is the best single pollinizing variety for all the hybrids grown in the

Mississippi Valley. Hybrids of the Sand Cherry (*Prunus besseyi*) produced by Hansen of North Dakota are also self-unfruitful, namely: Oka, Saca, Zumbra, and Compass. Compass can be used for a pollinizing variety, although it possesses considerable abortive pollen.

Planting plans for plums. For the United States, as a whole, it is recommended in plum plantings that at least every third tree in every third row be planted to a pollinizing variety. One or more limbs grafted to a pollinizing variety in each tree may serve equally well. However, both of these methods present difficulties in harvesting, and with the relatively large number of good pollinizers available, which are also desirable commercial varieties, the pollinizing trees should be planted preferably in rows. Two rows of one variety are more easily handled than a single row, and it is not uncommon to find four or even six rows of a variety being alternated with the pollinizer. With favorable weather at blooming time and the presence of bees in or near the orchard, such an arrangement is recommended. Bees are recommended in commercial plum orchards at pollination time in California. One hive per acre, scattered through the orchard should be sufficient.

ROOTSTOCKS FOR PLUMS

Plums do not come true from seed and, therefore, are propagated by budding on seedlings in the nursery similar to peach propagation. The plum is largely grown on plum stocks (Myrobalan), but it can be grown on peach and to a limited extent on apricot and almond. Seedlings of the Myrobalan plum are compatible with a wide variety of both Japanese and European plum varieties. Myrobalan stock is also tolerant to poor soil aeration and is adapted to a wide range of soils. In addition, it is not so inclined to throw up suckers from the roots. It is hardy, long-lived, and deep-rooted, although not particularly vigorous. It also gives very satisfactory results on deep comparatively dry soils. The brown color of the roots usually distinguishes the Myrobalan seedlings from other stocks used for plums.

In California, selected nematode resistant stocks of Myrobalan and Marianna plums propagated vegetatively are among the preferred rootstocks for standard variety plums.

Peach. In California, the nematode resistant stocks of peach also have been gaining popularity as desirable stocks for plums in shipping regions where the soil is relatively shallow, light, or of a sandy-gravel nature. Peach roots are relatively more shallow than plum roots, have a greater spread, and induce earlier growth of the top in spring. All Japanese varieties appear to be compatible with the peach, but this is not true for some European sorts. In California, pits of the Lovell and Salwey varieties are commonly used.

Apricot. Plums are grafted on apricots in regions where nematodes are a problem or where alkali may be relatively high in the soil. In California, apricot stock is not generally recommended because of frequent unsatisfactory unions between stock and cion. Some growers, however, have reported success.

Almond. Few commercial varieties of plums are propagated on almond stock. Although some varieties can be successfully grafted, others cannot. The almond as a rootstock is chiefly suited to the warm dry soils.

TOP-WORKING

There is often considerable interest in top-working plum trees in order to change the variety or to provide cross-pollination. There is a wide variation in compatibility among varieties of plums in top-working. Many Japanese varieties can be top-worked successfully on European varieties, but the reciprocal is not satisfactory. Poor results have been obtained in almost every case with the California Blue variety when used as either a stock or a cion.

The following European varieties make good growth when top-worked on peaches: Giant, Hungarian, President, Tragedy, Quackenboss, and French Prune. Grand Duke and Burton may give good results, but the top tends to outgrow the peach stock. This may be overcome by double-working, using a more congenial variety as an intermediate stock. The popular President plum gives poor results on Lovell peach. California Blue is not compatible with peach stocks; also, most prunes do not make successful unions, and the Diamond variety breaks badly. The peach makes a good stock for all Japanese varieties but the Climax.

When the almond is used for a stock, the following plum varieties make satisfactory growth: Apex, Duarte, Formosa, Clyman, President, Tragedy, and the Hungarian, French, and Standard prune. California Blue and Robe de Sergeant prune are not compatible with the almond; other varieties are questionable.

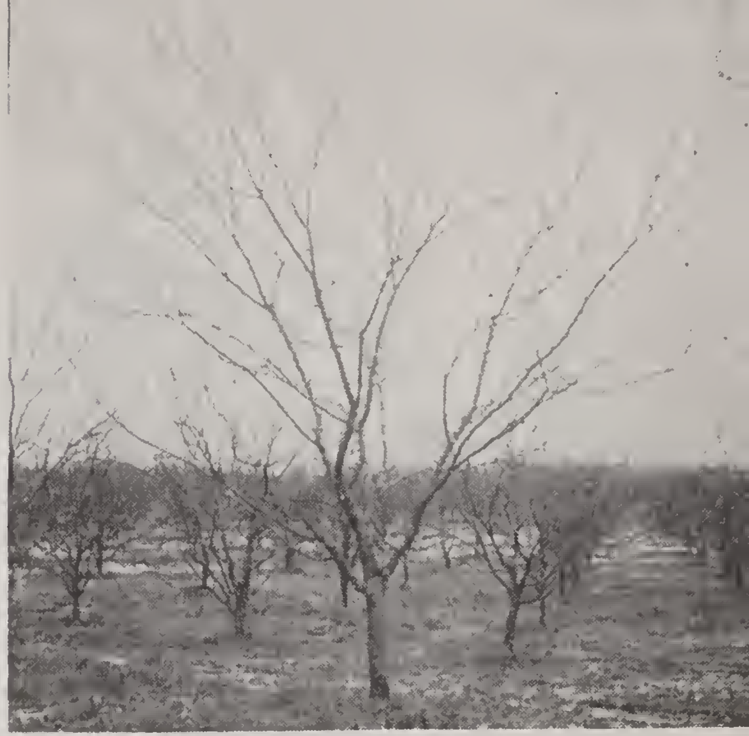
The apricot as a stock for plums has been a failure in most cases. However, some growers in California report success with the following varieties: Clyman, Giant, Kelsey, Satsuma, Tragedy, Wickson, Quackenboss, and the Imperial, Standard, French, and Sugar prunes. In almost every case, the plum tends to outgrow the apricot. Peaches, apricots, and almonds do not grow successfully when grafted on plums.

The usual method for top-working apples can be employed for top-working plums; these methods are described in Chapter VIII. The cleft- or bark-graft is most commonly used. Subsequent care of the graft is the same as that for the apple.

PRUNING PLUMS

Young trees. One-year plum trees arrive from the nursery as unbranched whips; the two-year trees are branched. Whips can be trained best by the "deshooting system" as described for the apple in Chapter IV. Subsequent training and pruning of these trees is similar to the procedure outlined for the apple in case of the modified-leader system, or for the peach (Chapter XIII) in case of the open-center system. The open-center system of training has been commonly used for most species of plums. Choice of a training system, however, should be governed by growth habit of the variety; those varieties that have a spreading habit, such as Burbank and many Japanese varieties, are perhaps better adapted to the open-center training system, whereas those which grow upright, such as Stanley, Santa Rosa, and Wickson, might easier and better be trained to the modified-leader system.

With upright-growing varieties, special attention is necessary to cut the branches back to outward-growing branches in order to develop a somewhat more spreading tree. With the naturally spreading varieties, such as Burbank, it is necessary to cut back the branches which are growing straight out or downward to upward- and outward-growing branches. Most European varieties develop into well-shaped trees even if very little pruning is done (Figure 184). In general, plum trees require relatively little pruning while young.



F. H. Beach, Ohio State University Agr. Ext. Serv.

Figure 184. A Stanley prune tree trained to modified-leader system with the central trunk larger than any lateral branch. The five or six strong lateral branches have wide-angled crotches and are well spaced up and down and around the central trunk.

Mature trees. The plum bears fruit laterally on one-year wood and on the vigorous spurs on older wood. It is important to encourage shoot growth of 10 to 24 inches on young trees and at least 10 inches on bearing trees. With trees making this much shoot growth, spur development is also encouraged and the productive capacity of the tree is increased considerably.

Bearing Domestica plum trees are pruned lighter than the peach or apricot. If the fruit will be dried, trees are pruned less than if it will be sold on the fresh market. After the trees have borne many crops, terminal growth may tend to become short and spur growth weak unless moderate pruning, fertilization, and good soil management have been practiced. With these trees, a thorough thinning out of the small thickly spurred branches is necessary; lower limbs and tops of main limbs should also be thinned out and headed back to vigorous laterals. Larger and fewer cuts are made on sugar prune trees, such as Agen and Imperial Epineuse, because it is less expensive and the margin of profit is usually too narrow to justify expensive practices on these varieties. Also, the branches tend to be brittle and break easily if allowed to become too long. About one-inch cuts are made back to laterals.

Because of the tendency of many Japanese varieties to overbear, a heavier pruning is recommended on this group of plums than for most European varieties; amount of pruning is about the same as recommended for the peach. The Japanese varieties bear fruit laterally on one-year wood similar to the peach; they also bear laterally and heavily on spurs. Judicious pruning of these varieties will materially reduce the subsequent expense and need for hand thinning of the fruit. Japanese trees growing on the more shallow soils may require somewhat heavier cutting in order to reduce the size of the crop, but increase the individual size of the fruits. The varieties in California which tend to set a particularly heavy crop and should be pruned somewhat heavier are Burbank, Beauty, California Blue, Climax, and in some instances Kelsey and Wickson. Moderate pruning is required for Formosa, Santa Rosa, Duarte, Gaviota, Wickson, and Kelsey. On upright-growing varieties, it is important to thin the branches and the center top of the tree sufficiently to admit sunlight to the center and induce more vigorous spur growth and better coloring of the fruit in this area.

In pruning both the young and mature trees, it is important to prune as little as possible to attain the desired results. Heavy pruning in any case should be avoided.

THINNING THE FRUIT

Thinning is a standard practice with plum trees carrying a moderate to heavy crop. The job is delayed until after the so-called June drop. With plums, thinning not only increases the size and uniformity in color of the fruit, but also reduces or prevents breakage of the tree, maintains good vigor (Figure 185), reduces insect injury, reduces spread of brown rot just prior to harvest, and decreases the labor required for handling the crop during and after harvest.

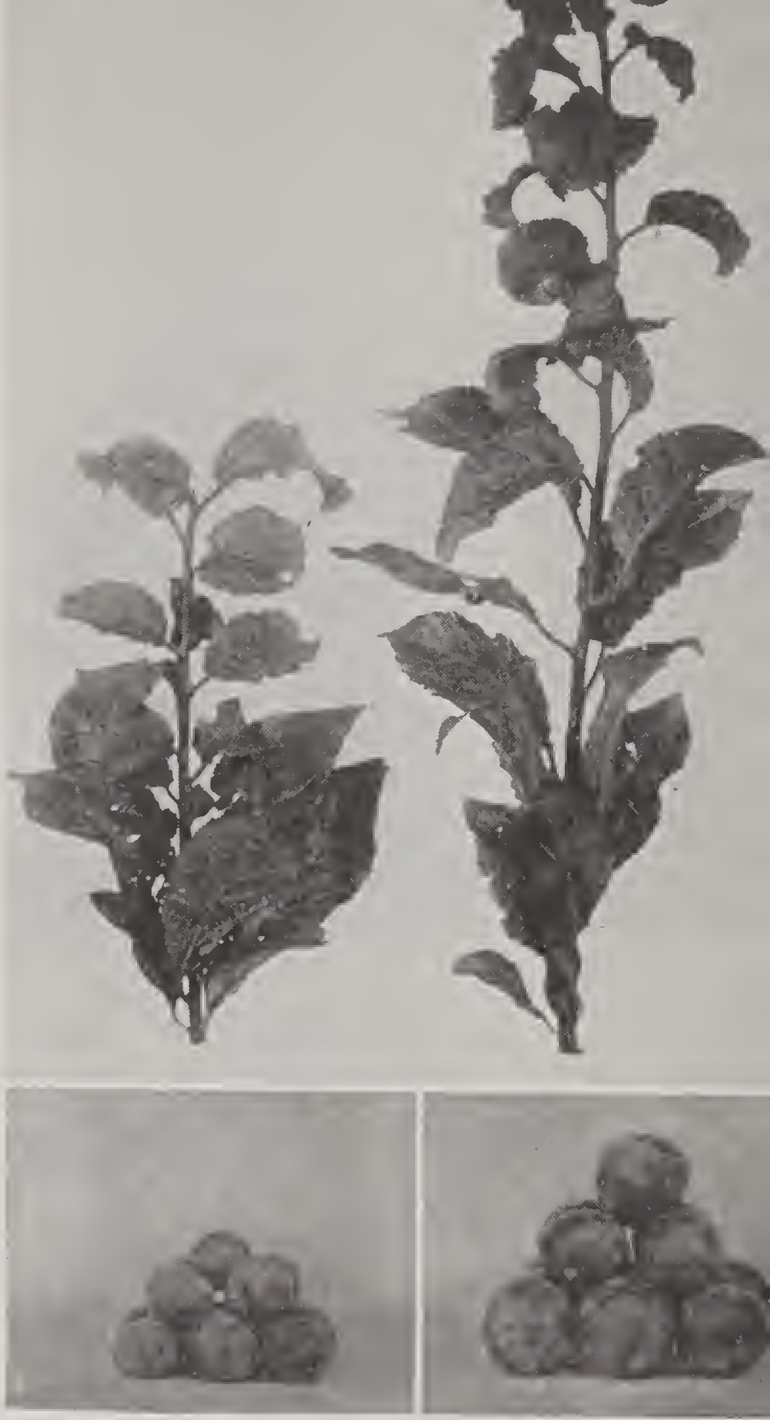
Although rather heavy pruning is practiced with varieties which tend to set fruit heavily, it is usually desirable to supplement this pruning by hand thinning. European varieties will usually attain better size in clusters than the Japanese and, therefore, are thinned less heavily. In favorable years for heavy production by Japanese varieties, they tend to set so many fruits that they are unable to properly size. Japanese varieties are probably thinned heavier than any other deciduous fruit.

In order to secure large uniform well-colored fruit, plums usually require a thinning of from one to three inches apart when mature, with the heavier thinning being recommended for the Japanese varieties. Burbank tends to set very heavy crops and requires relatively heavy thinning. Beauty probably demands the heaviest thinning of any. The varieties Santa Rosa and Climax tend to thin themselves as the fruits develop, and hand thinning where necessary is usually light. In sections of the country where strong winds are likely to occur while the crop is maturing, the thinning may be much lighter than otherwise.

SOIL MANAGEMENT

The same soil management systems as outlined for the young and bearing peach trees in the previous chapter will apply for the young and bearing plum trees. However, plum trees tend to perform somewhat better under sod or sod mulch than the peach. They will also make a better showing under neglect than almost any tree fruit, except the peas. Thus they are commonly found in home orchards.

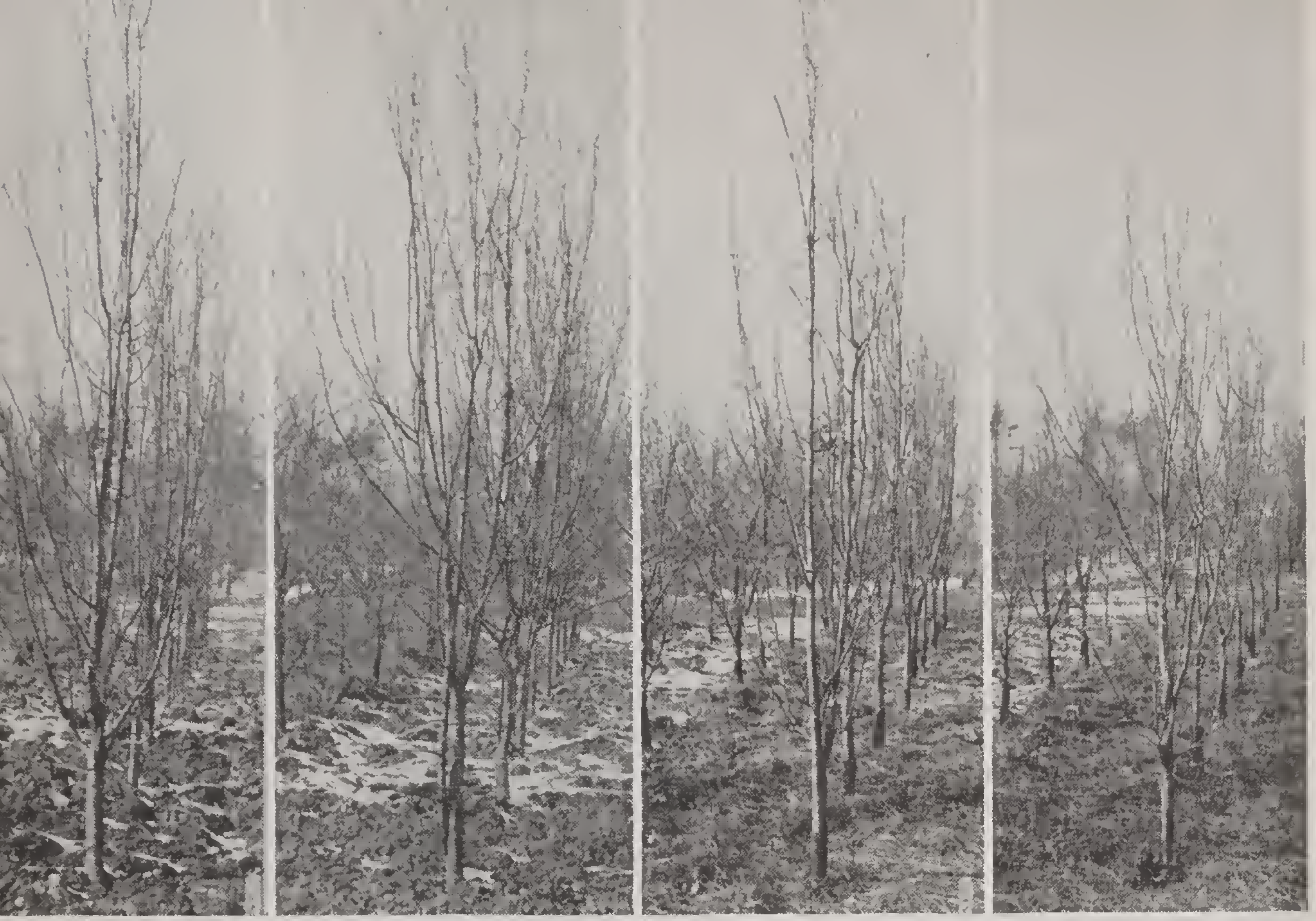
Fertilization. Plum trees planted on the heavier types of soil, in general, do not show the response to fertilizer applications that most deciduous trees exhibit. Where cultivation is practiced during a part of the year, the need for nitrogen is reduced, as indicated in Figure 186. Plum trees growing in sod without nitrogen fertilization are definitely dwarfed as compared with those in sod receiving nitrogen. Plum trees, however, respond well to a system of sod-mulch plus additional mulch, although there may be increased difficulty from curculio with this system in eastern orchards.



J. H. Waring, Maine Agr. Exp. Sta.

Figure 185. The effect of thinning a heavy crop of Lombard plums on size of fruit in Michigan. (Bottom left) Twelve fruits from an unthinned tree. (Bottom right) Twelve fruits from a thinned tree. The effect of this thinning carried over the following year in spite of crop failure the second year due to adverse weather. Note, (top left) corresponding shoot from the tree which was unthinned the previous year, and (top right) shoot from the tree thinned the previous year.

In California, the importance of fertilization is somewhat more generally recognized than previously. Manures, where available, are recommended at the rate of three to five tons per acre applied during the dormant season. Larger quantities may delay fruit coloring and maturity of early varieties. The manure should not be applied against the tree trunk, but under and somewhat beyond the spread of the branches. Because of scarcity of manures, chemical fertilizers, mainly nitrogen, are commonly used in California. Ammonium sulfate, nitrate of soda, or cyanamid give good response. Excessive quantities should be avoided. In California the usual rate of application is



A. J. Heinicke, Cornell University

Figure 186. Cultivated plum trees in New York on medium-heavy soil showed little or no response to applications of sodium nitrate. Trees in sod, however, which received 900, 900, and 1800 pounds per acre of sodium nitrate in successive years showed response to nitrogen but averaged only two-thirds as large as those on the cultivated plots. (Far left) cultivated; (middle left) cultivated with nitrate of soda; (middle right) timothy-rye sod with nitrate of soda; and (far right) timothy-rye sod without nitrogen fertilization.

from one to two pounds of ammonium sulfate for trees one to eight years of age and from two to three pounds for bearing trees. The fertilizer is spread evenly over the ground surface under the branches and during the dormant season. Trees in a sod system require more fertilizer than those growing under cultivation.

Irrigation. Irrigation is rarely practiced in the East or in some counties along the west coast of California. In the largest plum producing sections of the West, however, irrigation is a common practice. It may be done by furrows or basin flooding. Application of water by the furrow system in California varies from a 24-hour application every 12 to 14 days in some sections to a 72-hour application only two or three times a season in other regions, depending chiefly upon soil type and topography. In some heavy soils, water application periods have run to as much as five days in order to soak the soil to a depth of six feet. In the Sierra foothills, small streams are run through furrows for a period of three or four days; flooding each tree with a pool of water is not practical in this region due to sloping topography. The total water used in the entire season varies from 15- to 30-acre inches. Where winter cover crops are used, it is a common practice to irrigate immediately after the cover crop has been plowed under in spring, particularly where the climate tends to be dry. This aids decay of the cover crop and prevents the surface soil from becoming dry to the depth to which it was turned.

The soil about the tree roots should be kept moist and this can be determined by using a soil auger at weekly intervals during periods of drought. Trees should never be allowed to show signs of foliage wilting before irrigating. Where a deep-rooted alfalfa cover crop is used, special attention is necessary to see that the trees do not suffer from water deficiency through severe competition with the alfalfa.

RESISTANCE TO FROST AND WINTER INJURY

The average variety of European plum is about as resistant to cold as the Winesap or Baldwin apple. Lombard trees may be a little more resistant. Resistance to cold of flower buds varies considerably, with some less and others more resistant than apple flower buds.

Trees of the Japanese varieties may vary in cold resistance from the Kelsey, which is less resistant than peach trees, to Burbank, Abundance, and First which may be almost as resistant as European plums. Under good care, the flower buds of Japanese varieties are about as resistant as European plums. However, if the trees are in poor condition, the buds may be more tender than peach buds. Most flowers of Japanese plums are somewhat more resistant to cold than apple flowers and the young fruits appear to be at least as resistant as apple fruits of the same age. However, with Japanese varieties, the flower buds tend to open much earlier than apple flowers and are, therefore, more likely to be killed by the late spring frosts.

After relatively warm winters in California, some varieties of European plums, such as President, may be very slow to begin growth and many flower buds may be abscissed. On the other hand, trees of some varieties, such as Tragedy, may not be delayed to any extent. Chilling requirements of the Japanese plums, except for Climax, are considerably less than that for most varieties of European plums. After warm winters when President shows considerable injury, trees of Japanese varieties may also be delayed in starting, but, except for Climax, not enough to prevent their making good growth and setting a fair crop of fruit.

Prunus nigra is one of the most hardy to winter cold of the deciduous fruits grown in North America.

HARVESTING

The stage of maturity at which plums should be picked depends upon how they are to be utilized. For local trade, roadside markets, and for canning, it is best to pick plums when they are firm-ripe or almost mature. For long-distance shipping, however, and for jams and jellies, the fruit should not be fully ripe when picked. It should arrive at wholesale buyers or jobbers before fully ripe, and, thence, at retailers' stands in good, firm-ripe attractive condi-

TABLE 18

PICKING CONDITIONS FOR PLUMS (DOES NOT APPLY TO PRUNES), BASED UPON TEMPERATURES IN TRANSIT IN THE UPPER HALF OF REFRIGERATOR CARS

(Adapted from Allen)

VARIETY	WHEN SHIPPED STANDARD REFRIGERATION		WHEN PRECOOLED AND SHIPPED	
	Color Range	Pressure Test[1] Range (Pounds)	Color Range	Pressure Test[1] Range (Pounds)
Beauty	Straw tip to trace pink tip	13– 9	Pink tip to ½ red	8– 6
Formosa	Straw tip to trace pink tip	13– 9	Pink tip to ½ red	8– 6
Climax	Straw to pink tip	18–13	¼ to ½ red	12– 8
Santa Rosa . .	Trace red to ½ light red	18–12	½ to full light red	12– 9
Burbank	Straw tip to full straw with slight red	20–14	Yellow to ¼ red	13– 8
Wickson . . .	Straw tip to yellow tip	15–12	½ to ⅔ yellow	11– 8
Duarte	⅓ to ¾ light red	15–11	Full light to medium red	10– 8
Diamond . . .	Trace to ¾ light blue	20–15	Full light to medium blue	14–10
Giant	¼ to ¾ light red	16–11	Full light red	10– 8
President	½ to full light blue	16–11	Full blue	10– 7

[1] The figures given in this column refer to the number of pounds pressure required to force the plunger point of a fruit pressure tester $\frac{7}{16}$-inch in diameter into the flesh of the fruit $\frac{5}{16}$-inch in depth. Pressure tester is described in U. S. Dept. of Agr. Cir. 627, "Fruit pressure testers and their practical applications" by Mark H. Haller. 1941.

tion. Temperature at which the fruit is handled is the most important factor governing rate of ripening.

Most varieties of plums undergo rather marked changes in color within a period of about ten days to several weeks before becoming fully mature. Although these changes are gradual, they may be divided into several more or less distinct stages. With the Japanese varieties, the earliest stage occurs when the green of the stilar-tip changes to a lightish or yellowish green; this stage is often spoken of as "breaking." With most varieties, this yellowish green changes to a more decided yellow or straw yellow, after which the plums gradually assume their characteristic yellow or red. Commercially, the fruits are described as "straw tip," "slight color," "red tip," "three-fourths red," etc. With the blue or purple varieties, the color changes proceed from green, to greenish-blue, or reddish-purple, followed by dark blue or purple.

Color changes are especially noticeable and, therefore, have been considered the most important single test for maturity. As the color increases, there is normally a softening of the flesh. The firmness of the fruit when picked is closely correlated with the way fruit will hold up in transit. In California, a combination color-and-firmness-of-flesh standard has been suggested for a few of the leading plum varieties, as shown in Table 18.

The above table shows that plums can be picked somewhat more mature if they are to be shipped under precooled conditions. If the fruit will be shipped under standard refrigeration, it is best to place the more mature fruit at the base of the car where the temperature is 8° to 10° cooler. The later maturing firm-fleshed European varieties may be allowed to become more mature than the earlier more juicy thin-skinned varieties. Canning factories usually specify that the fruit for canning must be firm-ripe, and with maximum sugar content.

It is generally necessary to pick the trees from two to five times due to the fact that most varieties do not ripen uniformly. Commercially, the tendency is to rush the first picking of the earlier varieties, allowing some of the midseason varieties to become slightly overripe. The fruit should be picked slightly firmer and with less color as the season advances.

Yields. In eastern orchards, a mature plum orchard may yield between three and five tons per acre, or one to one and one-half bushels per tree. The average for all orchards, however, is considerably less than these figures. Prune trees yield somewhat more than plum trees, or two to three bushels per tree. Japanese varieties bear at from three to five years of age, while the Domestica varieties bear about two years later. Native American plums require a somewhat longer period to come into bearing.

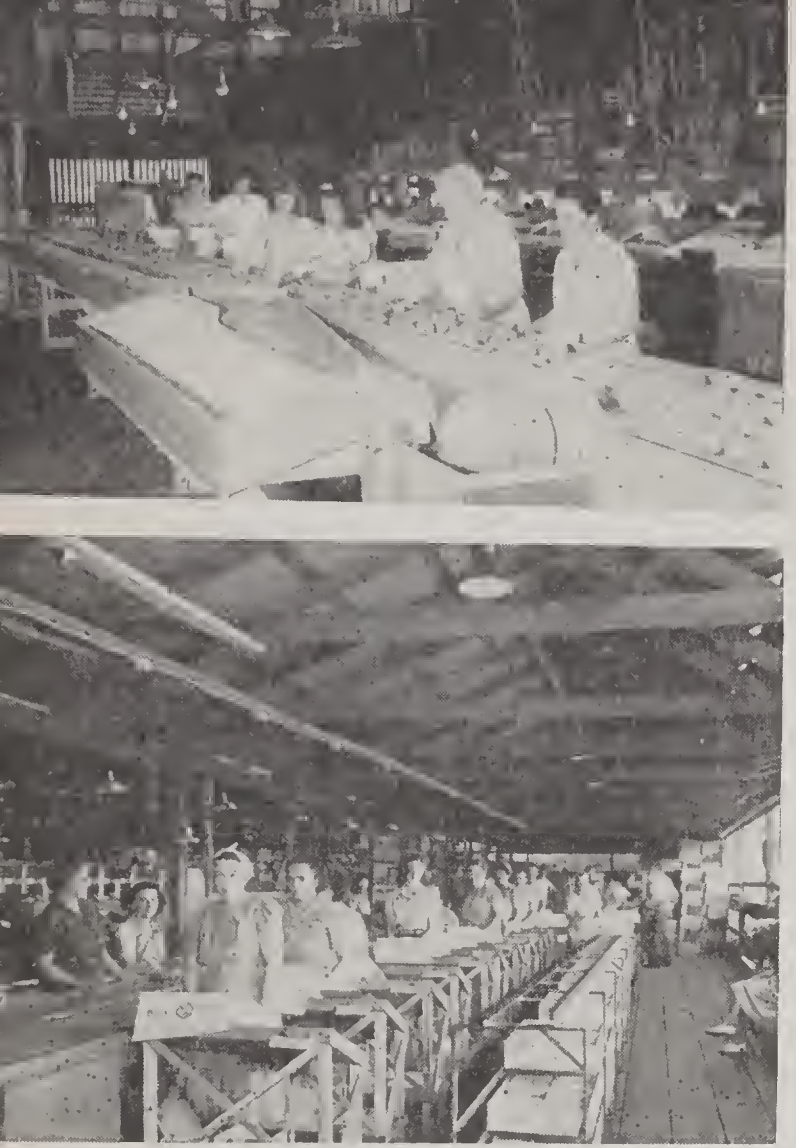
The trees tend to come into bearing earlier on the Pacific coast and yield much larger crops. The average yield per acre in California runs about three tons, but the better growers may secure from six and one-half to seven and one-half tons per acre.

Picking and handling methods. Special precautions should be taken to remove the fruit from the tree with stems intact and to avoid breaking the skin. Due to the perishable nature of plums, they must be handled with extreme care. In filling the picking receptacle and sizing, grading, and packing, it is important to preserve as much of the bloom on the skin surface as possible. It is well to keep the fruit in the shade of the trees immediately after picking. Handle the fruit from tree to storage with little or no delay. Plums may be transported from the orchard to the packing shed in either picking baskets or in lug boxes; the fruit receives one less handling when picking baskets are used.

Picking for distant shipment should be done early in the day and the fruit taken immediately to the packing shed, or, picking can be done in late afternoon and the fruit left in the orchard to cool overnight. If the plums are to be used in canning, they are handled mostly in lug boxes with somewhat less care.

If the prunes are to be dried, the ground beneath the tree in the coastal areas of California is carefully smoothed before the prunes begin to naturally drop. The prunes continue to drop over several weeks and it is necessary to gather them at least several times during a season. In the warmer interior valleys, the abscission layer may develop slowly or fail to form entirely and the fruit must be knocked or shaken from the tree.

In order to remove wax from the skin of prunes, they are dipped for a few seconds to almost a minute in a hot lye solution containing one pound of lye in 20 gallons of water. The prunes are rinsed and rolled over a needle board which pierces the skin in many places and makes it more permeable



A. J. Schoendorf, California Fruit Exchange, Sacramento

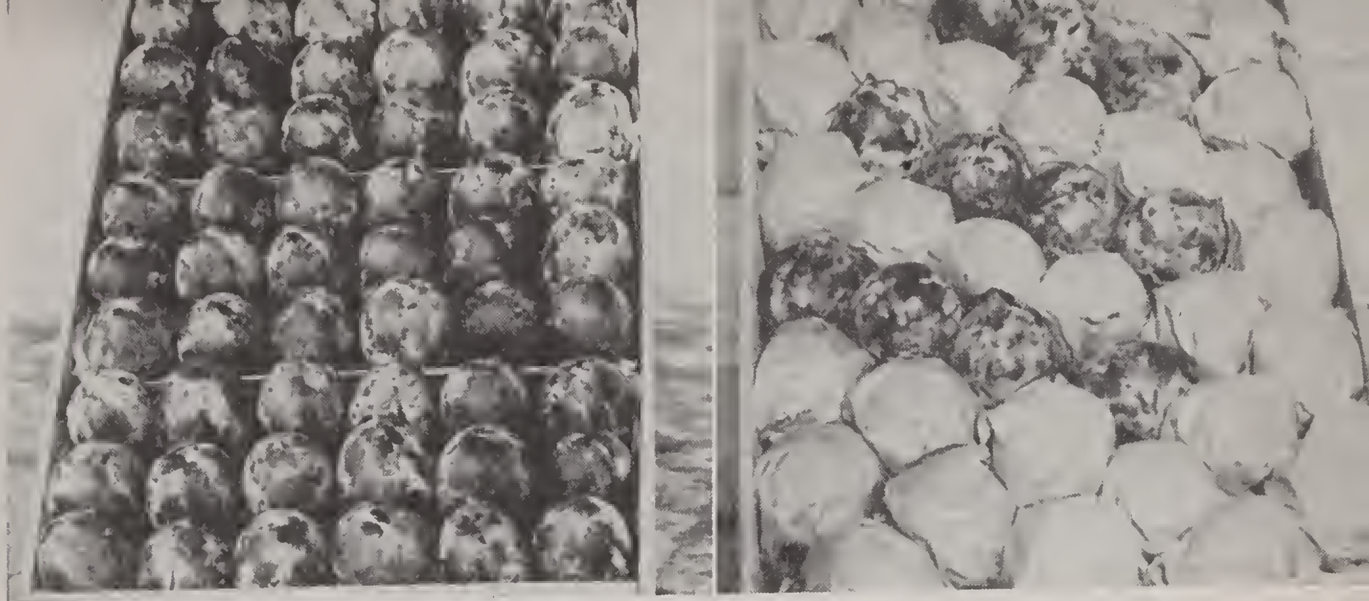
Figure 187. Plum-packing scenes in California, showing (top) the moving belt, overflow feature in left foreground for odd-size fruit; packers and superintendent at right. (Bottom) A view of box packing stands and metal conveying equipment at right for empty and packed boxes.

to water. The prunes are then arranged on drying trays and placed either in the sun or in dehydrators. Lots of prunes of the same variety and among different varieties may vary in their loss of water during drying. The drying ratio refers to the number of pounds of fruit picked from the ground which are required to give one pound of dried prunes. About two to three pounds of fresh fruit are required to give one pound of dried fruit; naturally, it is determined in part by the dryness of the fruit when it falls and when it is gathered. Sugar content is probably the most important factor affecting the drying ratio.

PACKING

Although some of the large growers in California individually pack their own fruit, there is a strong tendency toward community packing (Figure 187). Plum sizing is done either by hand or mechanically by weight or by size. The fruit is sorted into one or two grades by maturity, color, and blemishes according to the requirements of the U. S. Marketing Service or the particular state standards. These qualifications are usually established by the growers themselves in order to protect and maintain a standard and quality of fruits from a given state or region. Some growers and packing concerns have been exceeding the minimum requirements of the standard law by issuing an extra fancy grade. Returns from this higher grade have usually been justified, especially during heavy crop years.

Plums are received at the packing house in growers' lots in field lugs containing approximately 30 to 40 pounds net. For the equipment shown in Figure 187, the fruit is emptied, one box at a time, at the head end of the flat belt. The belts are not standard in size and capacity, but are calculated in each instance to conform with the capacity and requirements of the particular packing house. They usually range in length from 40 to 70 feet over-all. The main packing belt varies in width from 18 to 30 inches, and the return



California Fruit Exchange, Sacramento

Figure 188. (Left) The peach box is frequently used for large-sized plums, the fruit being packed in two layers in the same manner as peaches. Large fruit numbering less than 100 per box are often wrapped. (Right) A three-basket pack of President plums arranged systematically in a peach box.

belt in width from 8 to 18 inches. A section of the belt immediately following the space on which the fruit is dumped, usually from 8 to 15 feet in length, is used as a sorting space in which overripe and cull fruits are removed from the belt. The fruit is then carried past the packers, who, in the process of packing, size the fruit by eye, and select the size they require for the particular crate on which they are working. The fruit flows past the first packer to the next one in line, who in turn performs a similar process, and so on until the end of the packing line is reached. Enough packers are employed to consume about 75 per cent of the fruit passing them. The remaining fruit comes back on a return belt (not shown in Figure 187). It is common practice to utilize three or four packers to pack fruit on the return belt.

The overflow feature in Figure 187 is used to accumulate sizes that are not in abundance when the fruit arrives at this point in the packing line. This fruit is allowed to accumulate in the overflow, and, later, when sufficient fruit has accumulated, it can be packed separately.

Containers. In the East, plums are often sold locally in Climax baskets of the four- and twelve-quart size. One-half and one bushel tub baskets also are commonly seen. Small plums may be shipped in berry crates.

For eastern shipment from California, plums are packed in either four-basket crates or in peach boxes (Figure 188). The standard four-basket crates are from four to five inches deep with two or three layers, depending upon the size of the fruit; the count may range from 112 to 340 fruits per crate. This crate holds four three-quart till baskets and is 16 inches wide and 16⅛ inches long. Each basket may be sold as a separate unit in the retail trade. There is danger of rim cutting of the plums in these boxes and this may be prevented by placing heavy paper collars just inside the top of the baskets.

Peach boxes as described in Chapter XIV are also popular with the standard packs varying from 78 to 105 plums per box. Fruit for local markets in California is largely sold in open lug boxes.

In Idaho, Italian Prunes for the most part are shipped in one-half-bushel tub baskets and this package is used to some extent for prunes coming from certain sections of Oregon and Washington. The standardized lug box in Oregon is 3⅜ by 10½ by 15 inches inside dimensions. A ½-inch cleat makes the total depth 3⅞ inches. It is usually packed 16 pounds net weight with one or two faced layers backed by a jumble pack.

Packing the container. In the four-basket crate, the individual baskets contain less fruit in the bottom layer than in the middle and top layers. This makes arrangement of the fruit somewhat difficult. This is largely overcome, however, by the use of cardboard shims between the bottom and middle, and also between the middle and top layers. The shims have the advantage of preventing the fruit from settling in transit.

Most varieties are placed in the basket "straight up" with stems downward (Figure 188). With oblong varieties, however, such as Grand Duke, Tragedy, and Giant, leaning or tilting the specimens slightly is recommended.

Plum packing is more tedious than for most fruits and considerable experience is usually necessary before one can master the many details which govern the difference between a smooth solid uniform pack of proper height and one which lacks these preferred characteristics. A good packer will be able to distinguish small differences in size or shape of fruits and know the proper place and arrangement for each size or shape.

Marking. Each container is marked on the outside with the name and address of the orchard, the packer, the variety, net weight, and approximate number of fruits (within four of the true count in California) in the container or the subcontainer. Also, the plums may be stamped according to the count on two adjacent sides of the top layer in the container or subcontainer. For example, the number of fruits on adjacent sides of a commonly used subcontainer is the four by five size. Peach boxes are marked with the number of fruit they contain.

Transporting. In transporting plums from the packing house to the shipping point, it is recommended that each box be placed squarely on top of the box below. The boxes should be stacked firmly so that there will be no possibility of shifting. A light canvas over the top of the load will protect the fruit from sun and dust. Hauling by truck to local markets is largely done during the cool night hours.

STORAGE

Fruit of most varieties of Domestica plums can be held from two to four weeks at 30° to 32° F. during floods on the market. At higher temperatures of 37° to 50° F., which is usually the temperature range in a refrigerator car, plums will not keep so long. Fruit of certain varieties, such as Tragedy, Grand Duke, and President, will keep for nine weeks if they are harvested when full-grown and somewhat sweet, and held at a temperature of 30° to 32° F. If harvested greener, they may show various injuries at these temperatures; better flavor is obtained if plums are held at the higher temperatures of 37° to 50° F. A special effort has been made in California to select Domestica plum varieties which will develop an acceptable flavor when harvested green enough to go across the continent in refrigerator cars and remain sound several days in retail stores. President has a particularly good quality in that it can be left upon the trees until it becomes full-grown and rather sweet, be sent across the continent, and be sold in good condition on the eastern market. The best period for harvesting Italian Prune is when the soluble solids are about 17 per cent, as measured by a refractometer.

SHIPPING PLUMS

Plums are shipped under refrigeration from the Pacific coast states to the East. The minimum carload is 26,000 pounds;[1] this consists of 1000 crates, each weighing 26 pounds gross. Crates are loaded in tiers five wide and ten high from each end of the car halfway to the door; the crates are nine high throughout the center of the car. There are 21 tiers from one end of the car to the other, eleven at one end and ten at the other. The cars may contain a single variety or mixed varieties of plums with or without other fruits such as peaches or grapes.

Fruit entering an iced refrigerator car at 80° F. will cool to 45° in the floor layers in 24 hours, but the top layers do not reach this temperature until about the seventh day. Therefore, precooling of the fruit to 40° F. is highly desirable. This is commonly done by means of fans at the upper bunkers which circulate air over the ice and throughout the car. By this system, it requires from 20 to 24 hours to bring the fruit temperature below 40° F. Fruit also may be precooled in a special room or cold storage plant before entering the refrigerator cars. If precooling is to be most efficient, fruit temperatures in the center of the packages should be reduced to 40° F.

Many new refrigerator cars are equipped with blower fans under the floorboards at the bunkers. These fans can be driven for precooling by motors attached outside the car, or they can be operated while the car is in motion by a friction wheel against the car wheel. Precooling is now generally used in California.

MARKETING

Plums grown in the East are largely sold to local markets or on roadside stands, for fresh consumption or for canning. Appearance of small baskets of fresh plums can be improved on the counter by mixing plum varieties of different color and/or by mixing plums with peaches, grapes, and perhaps other currently ripening fruits.

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[1] Minimum load limits were raised by Office of Defense Transportation during the last war.

In the West, plums are sold through shipping agencies which deal with brokers, or which have their special representatives in the East. The fruit may be sold to an individual at a private sale, or it may go to public auction; this is usually determined by the sales manager of the shipping agency. Although plums are a perishable fruit, they are being shipped to all parts of the United States and some are being exported.

One of the major problems in normal times with marketing of plums is to move the large quantities of fruit from the West at prices satisfactory to the growers and shippers. This situation is being met by advertising campaigns put on by the marketing agencies and by sending special representatives to the eastern markets to encourage and maintain good will. Efforts are also being made to distribute California plums, for example, to the smaller cities and towns throughout the United States. In this selling program, the grower himself must realize that small fruits of miscellaneous varieties and of inferior quality will bring a price but not a profit. The eastern market requires relatively few varieties which are shipped in large quantities. As stated previously, they are not interested in small batches of a large number of different varieties.

Review Questions

1. State briefly where plums are grown in the United States on a commercial basis, and for home consumption and local trade.
2. Name the different groups and subgroups of plums.
3. What is the difference between a plum and a prune?
4. List 2 leading plum varieties in the East and 2 in the West, stating to which group each variety belongs.
5. What governs the choice of varieties of plums in California; in New York?
6. What is the most common rootstock for plum trees? Why are other stocks used for plums in California?
7. Can European varieties of plums be successfully top-worked on Japanese varieties?
8. Why is the bearing Japanese plum tree pruned more heavily than the European type?
9. Describe the precautions necessary in training the Wickson variety of plum to the modified-leader system.
10. At what time and at what distances are Japanese and European plum fruits thinned?
11. What is a good system of soil management for young plum trees growing on a 10 per cent slope in medium heavy soil in your state?
12. Where and when is irrigation practical with plum trees?
13. At what stage of maturity should plums be harvested for long distance shipping, for roadside markets, for drying, and for canning?
14. What yield can you expect from mature European plum varieties in your state?
15. What types of containers are popular for shipping plums in California; in Idaho; in Michigan?

16. At what temperature and how long can plums be stored?
17. Discuss briefly how plums are shipped from California to the eastern market?

Suggested Collateral Readings

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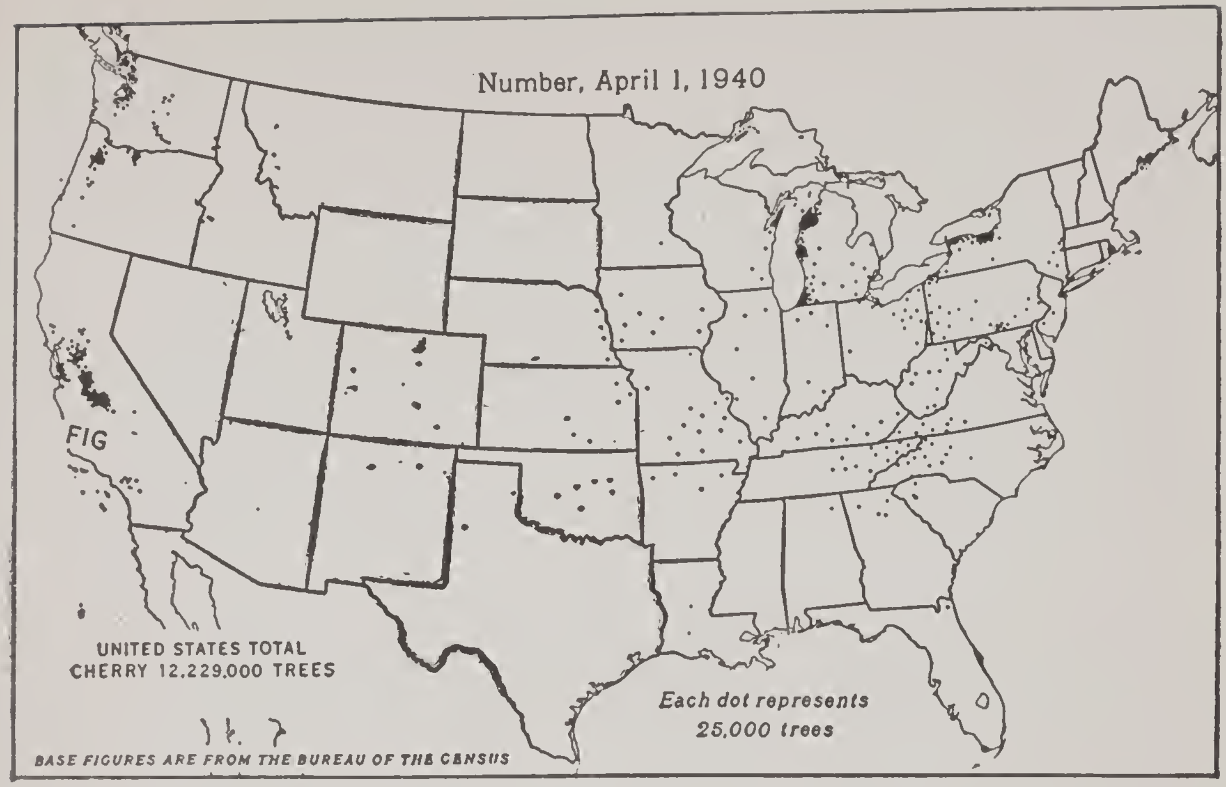
CHAPTER XVI

Cherry Culture

The cherry is exceeded in importance among stone fruits by the peach, plum, and apricot. It has always constituted a more or less important part of home fruit gardens in the North, but it was not until the 1920's and 1930's that extensive commercial cherry plantings were made. The increased plantings were due principally to the development of the commercial canning and frozen-pack industries. These industries have made cherries available to domestic and foreign consumers every day of the year instead of for only a four- to six-week period within a short distance of where they were raised. This combined extension of markets and marketing season has greatly increased the demand and likewise the production of cherries.

The total number of cherry trees in the United States in 1945 was 11,989,659 which is a decrease of over two and one-half million trees since the 1900 Census. The decrease in tree numbers in such states as West Virginia, Virginia, Kansas, Missouri, and Nebraska was probably due in part to the disease factor. In the northern states and in California, on the other hand, there has been a steady increase in numbers of cherry trees in recent years. This may be due to the fact that the cherry is better suited to cooler climates and also to the commercial fruit canneries and frozen-pack establishments which have developed in the cherry-producing sections.

As shown in Figure 189, cherries are largely grown above the Mason and Dixon's line. This is mainly because cherry diseases and insects are difficult to control in the southern United States and, as indicated above, because the climate may be too hot during the summer. In the northern states, commercial cherry orchards are very much localized. Thus, over half of the bearing trees in Wisconsin are located in Door County; three-fourths of the cherry trees of Oregon are located in the Willamette, Umpqua, and Walla Walla Valleys, and about The Dalles. In Michigan, most of the cherry trees are



U.S.D.A. Bureau of Agricultural Economics

Figure 189. Most important cherry regions in the East are in western Michigan, western New York, and in Door County, Wisconsin. Important regions in the West are in central California, northwestern Oregon, and the well-known fruit regions of Washington.

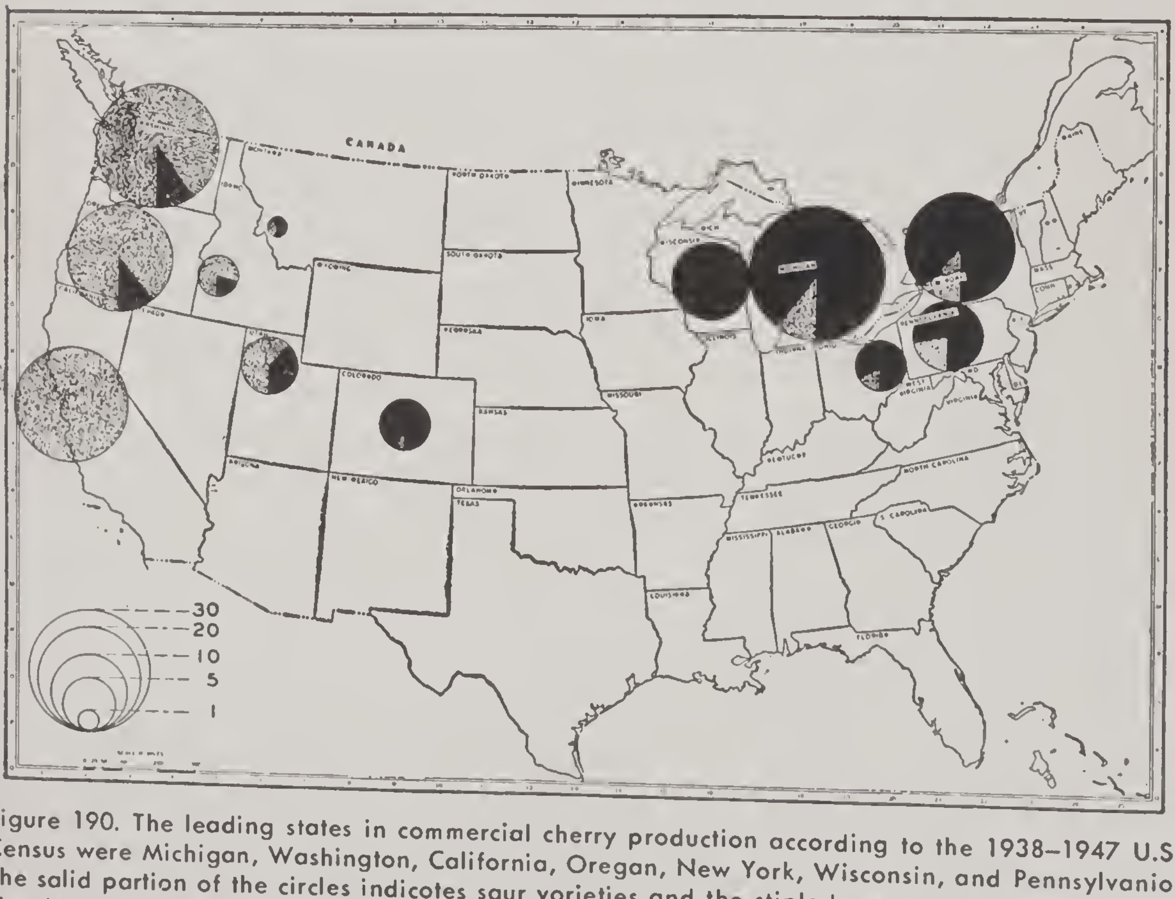


Figure 190. The leading states in commercial cherry production according to the 1938–1947 U.S. Census were Michigan, Washington, California, Oregon, New York, Wisconsin, and Pennsylvania. The solid portion of the circles indicates sour varieties and the stipled areas sweet cherries. Sour cherries are largely grown in the East whereas sweet cherries are concentrated in the West. (Numbers at lower left represent thousands of tons.)

grouped along the shores of Lake Michigan. In New York, cherry trees are largely confined to Wayne County and along the shores of Lake Ontario. It should be recognized, however, that cherries are not limited to these concentrated commercial areas. They can be grown in many of the states, as indicated in Figure 189. Cherries are particularly adapted to home gardens where occasional crop failures may be of little concern to the owner.

Relative production of sweet and sour cherries by state is shown in Figure 190. Although sweet and sour cherries are grown both in the East and West, the sour cherries (black areas) are largely grown east of the Rocky Mountains, whereas sweet cherries (stippled areas) are concentrated in the West. The ranks of states in production of all varieties of cherries (1937–46 average) and sweet and sour varieties separately (1938–46 average) are as follows:

All Varieties		*Sweet Cherries*		*Sour Cherries*	
	Tons		Tons		Tons
1. Michigan	38,190	1. California	27,444	1. Michigan	34,722
2. Washington	29,080	2. Washington	25,178	2. New York	17,256
3. California	26,860	3. Oregon	20,767	3. Wisconsin	10,922
4. Oregon	22,305	4. Utah	3,256	4. Pennsylvaia	5,689
5. New York	19,575	5. Michigan	3,089	5. Washington	5,356
6. Wisconsin	10,890				

CHERRY VARIETIES

Most of the cultivated cherries grown today have been derived from two species; namely, the sour cherry *(Prunus cerasus)* from which both the light- and dark-colored sour cherries have developed, and the sweet cherry *(Prunus avium)* from which the sweet varieties and the Mazzard types have arisen. The Duke cherries, intermediate in type, are considered to be hybrids between the sweet and sour groups. Other species of cherries have not produced varieties which are grown extensively on a commercial scale for their fruit. The Mahaleb cherry (*Prunus mahaleb*), native to Europe, is used as a rootstock upon which standard cultivated varieties are budded. The Mazzard wild sweet cherry is also used for this purpose. A Chinese species *(Prunus tomentosa)* has been grown to some extent in the Upper Mississippi Valley and in the Canadian prairie provinces where winters are too adverse for common sweet and sour varieties. Several of the Japanese species of cherries are grown widely for ornamental purposes in the United States (notably near the Washington Monument). The Bird cherry (wild sweet) is valued only for its wood.

Most of the important cherry varieties grown in the United States are of European origin, coming from France, England, Holland, and Germany. Because of the fact that the cherry is inclined to reproduce comparatively true to type from seed, many similar seedlings have developed which can hardly be placed under the same variety heading. As a result, one speaks of a cherry as Morello-like, Napoleon-like, or Montmorency-like.

The cherry variety list has probably undergone less change within the last generation than variety lists of almost any other deciduous fruit. This is evidence that the present commercial varieties are fairly satisfactory from the standpoint of trade specifications, although there is undoubtedly much to be desired in the varieties. This also indicates that the prospective cherry grower can plant an orchard with considerable confidence that the variety list will be satisfactory for both present and future market demands.

There are at least 1,145 cherry varieties (as described by Hedrick), which have been grown at one time or another in America. There are only a few, however, which can be grown commercially and which meet a ready market demand. Commercially important varieties belong to either the sweet or sour (tart) group. Sweet cherries are used principally for fresh-fruit dessert, although increasing quantities are being canned, frozen and made into maraschino cherries. The sour cherries make up the great bulk of the frozen and canned cherries for use in restaurants, soda fountains, bakeries and in homes for pies, ice cream, sauce, preserves, and other desserts. In fact, sour cherries are so important for pies that they are frequently referred to as "pie cherries."

The sweet varieties. Most of the sweet cherries belong either to the "Heart" or "Bigarreau" group. Those varieties belonging to the Heart group have a comparatively soft flesh and many of them are heart-shaped, although some varieties are globose or oblate. Heart cherries may be further divided into dark-colored varieties with reddish juice and light-colored varieties with colorless juice. Among the light-colored Heart varieties are Coe, Ida, Elton, and Governor Wood. Dark-colored varieties are represented by Black Tartarian and Early Purple.

Varieties of the Bigarreau group are usually roundish in shape and of firm crisp flesh. There are some, however, that are as typically heart-shaped as those of the Heart group. Examples of the black Bigarreau type are Windsor, Republican, Bing, and Lambert, while varieties of the light type include Yellow Spanish and Napoleon. Sweet cherries of the Bigarreau group have gained the most commercial prominence. Those of the Heart group, as a whole, tend to have poor-keeping and shipping qualities, although some are excellent for home use and local market sales.

In California, the Bing, Lambert, Republican, and Napoleon are the leading commercial varieties of sweet cherries. In New York, the Black Tartarian, Schmidt, Napoleon and Windsor are grown commercially, while the Early Rivers, Victor (yellow flesh ripening before Napoleon), Emperor Francis, and Geant D'Hedellingen are recommended for trial. In Ohio, Windsor has been the most dependable sweet variety. Lambert and Napoleon are also suggested. It is interesting to note that Bing tends to crack at maturity more than other sweet cherry varieties under Ohio and eastern conditions, whereas Bing is one of the more resistant varieties to cracking in Idaho, followed by Black Tartarian, Napoleon, Lambert, and Republican. Cracking of cherries is associated with high humidity caused by heavy dew or rainfall shortly before harvesting. The Napoleon (Royal Anne) variety is probably the most widely planted sweet cherry in America.

Sweet cherry varieties which have originated in America as seedlings include Governor Wood and Waterhouse of the yellowish varieties; and Burbank, Chapman, Oregon, Bing, Lambert, and Republican of the dark-red good-shipping varieties.

The sour cherries. The sour cherries contain many varieties, but only three usually receive attention from a commercial standpoint and of these, the Montmorency is outstanding. It is used chiefly for canning and freezing. The Early Richmond ripens a week to ten days earlier than Montmorency, but it yields less and the fruits are slightly more acid and somewhat smaller in size than Montmorency. Early Richmond is planted mainly to extend the ripening season for local fresh market trade. English Morello is a relatively small spreading tree which bears medium to small, dark red to almost black cherries that are tart and of good quality. English Morello matures relatively late and will hang on the tree for a long time after maturity without deteriorating. It requires thorough spraying because the foliage is highly susceptible to the leaf spot disease. English Morello has a limited demand on local markets and a very limited demand for commercial canning.

The Duke cherries contain less important varieties than the sweet or sour groups. Only three Duke varieties are planted to any commercial extent in the United States; namely, May Duke, Royal Duke, and Late Duke. Other varieties grown occasionally in the East are Brassington and Reine Hortense.

General variety considerations. As pointed out previously, the cherry varieties, like other fruit varieties, are limited in commercial adaptability to rather definite areas. Disadvantages of the sweet cherry are the fact that although it is as hardy in wood as the peach, it does not recover as well from winter injury; it blossoms early in the spring, and the flowers are very susceptible to cold and frost injury. The trees do not thrive on heavy or poorly drained soils. Likewise, the sour cherry is adversely affected by poor soil drainage (Figure 191) but not to as great a degree as the sweet cherry. According to Gardner, poor soil levies approximately a 25 per cent tax on the sour cherry industry in Michigan.

The sour cherry tree is about as hardy as some apple varieties, but its swelling flower buds and flowers are relatively tender to cold. In Michigan, one crop out of three in the average commercial orchard is lost to spring frosts; in the one-third of the orchards on the best sites, however, crop loss from frosts occurs less frequently than once in five years. Gardner states that "most growers, if asked to name their most serious problems or limiting factors (in cherry growing), would mention frost injury to blossoms in the spring, summer defoliation by leaf spot or shot-hole fungus disease, and the difficulty in obtaining what they regard as a satisfactory price for their product." To these troubles in recent years might be added the yellow-leaf virus disease which has become one of the most important limiting factors in sour cherry production in eastern states. The reader is referred to the

Suggested Collateral Readings for description and control.

There has been relatively little work in cherry breeding in the past decade, which might indicate, as stated earlier, that growers are perhaps more satisfied with varieties of cherries than with peaches, apples, and other fruits. The failure to develop new varieties of cherries, particularly the sweet cherry, may be due to the fact that cherries cannot be grown over such a wide area of the country as the peach and the plum, and to the failure of the seed to germinate and grow, especially with the sweet varieties. The chief objectives in the breeding programs today are to obtain high-quality sweet varieties that will prove more hardy in trees and blossom characters than many of those now available for planting. Even in the limited areas where sweet cherries will grow, there is definite need for firm-fleshed varieties that do not crack and that will ripen over a long season. At present, there is no firm-fleshed early-ripening variety of the Bigarreau type. There is also need for developing brown rot resistant varieties for the southern United States. The Duke varieties are excellent cherries, but there is a definite need for higher-producing varieties.

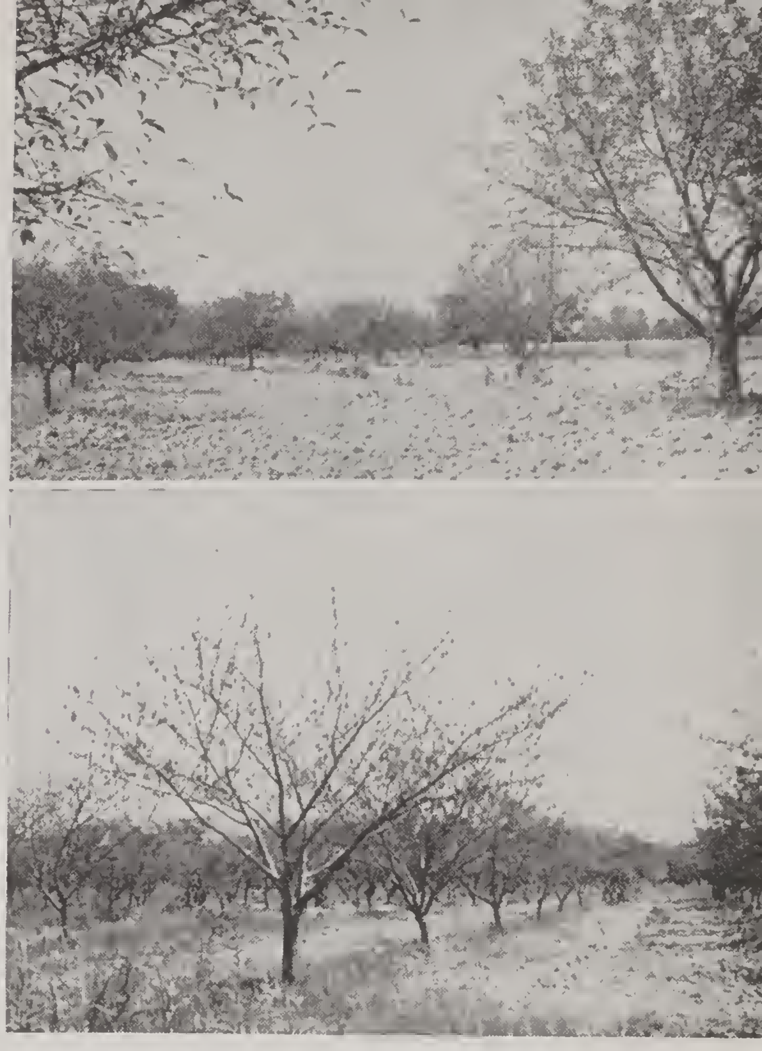
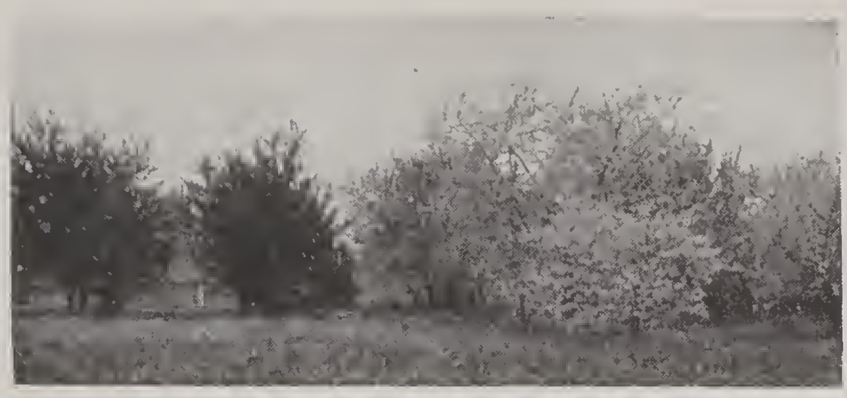


Figure 191. Both sweet and sour cherries grow poorly or die on heavy soils with poor drainage, particularly sweet cherries. (Top) Note missing Montmorency trees in low poorly drained area in center of orchard. (Bottom) Ten-year Montmorency trees dying in July in heavy poorly drained soil following an unusually wet spring in northern Ohio.

POLLINATION

Sweet varieties. All sweet cherry varieties which have been tested both in the United States and Europe have been found to be self-unfruitful as evidenced by the development of practically no fruit following self-pollination. All commercial varieties of sweet cherries have viable pollen, but not all varietal combinations are fruitful. There are many cross-incompatible groups of sweet cherries which are usually closely related either as seedlings or bud mutations of a parent variety. Varieties within a group should not be planted together without a pollinizer. These cross-incompatible groups include: (1) Bing, Lambert, Napoleon, Emperor Francis, and Ohio Beauty; (2) Windsor and Abundance; (3) Black Tartarian, Black Eagle, Knight's Early Black,



Ohio Agr. Exp. Sta.

Figure 192. Sweet cherry trees (right) may be in full bloom ten days before the sour cherries (left) begin to bloom. Hence, sour cherry trees will not provide cross-pollination needed by sweet cherry trees.

Bedford Prolific, and Early Rivers; (4) Centennial and Napoleon; (5) Advance and Rockport; (6) Elton, Governor Wood, and Stark's Gold; and (7) Early Purple and Rockport. Sweet cherry varieties must be properly interplanted for effective cross-pollination. Sour cherries cannot be used as pollinizers for sweet cherries since their blooming periods do not overlap (Figure 192). The Duke varieties are not reliable for use in cross-pollination with sweet cherries.

In the East, blooming seasons of the commonly grown sweet cherry varieties usually overlap sufficiently to provide good commercial crops. However, in the West, somewhat more care is needed in the selection of varieties on the basis of blooming dates. Early-blooming sweet cherries include Black Tartarian, Black Republican, Advance, Burbank, Chapman, Black Heart, and Early Purple. Napoleon, Rockport, Bing, Pontiac, Longstem Bing, and Lambert are considered late-blooming, and Deacon has been interplanted among these varieties in Washington and British Columbia as a pollinizer. The Black Republican and Black Tartarian usually overlap sufficiently in blooming period to pollinize most of the late-blooming sweet varieties.

Sour varieties. The common varieties of sour cherries; namely, Early Richmond, Montmorency, and the Morellos are sufficiently self-fruitful to give commercial crops when planted in solid blocks, provided sufficient pollinizing insects are available.

Duke varieties. The Dukes are similar to the sweet varieties in that cross-pollination is needed for commercial crops. With good cross-pollination, however, Duke varieties in general are relatively low-producing, apparently due to the unbalanced constitution of the reproductive cells. The May Duke and Royal Duke are usually the most productive. The late-blooming sweet cherry varieties are used for cross-pollinating the early-blooming Duke varieties, such as May Duke. Among the late-blooming sweet varieties are Napoleon, Windsor, and Governor Wood. The Early Richmond and Montmorency sour cherries are effective as pollinizers for most late-blooming Duke cherries, Olivet being one exception.

Planting plan. In both the East and the West, it is recommended that where cross-pollination is required, at least every third tree in every third row should be planted to the pollinizing variety, or, in other words, a pollinizing tree should be adjacent to every tree needing cross-pollination.

ROOTSTOCKS FOR CHERRY TREES

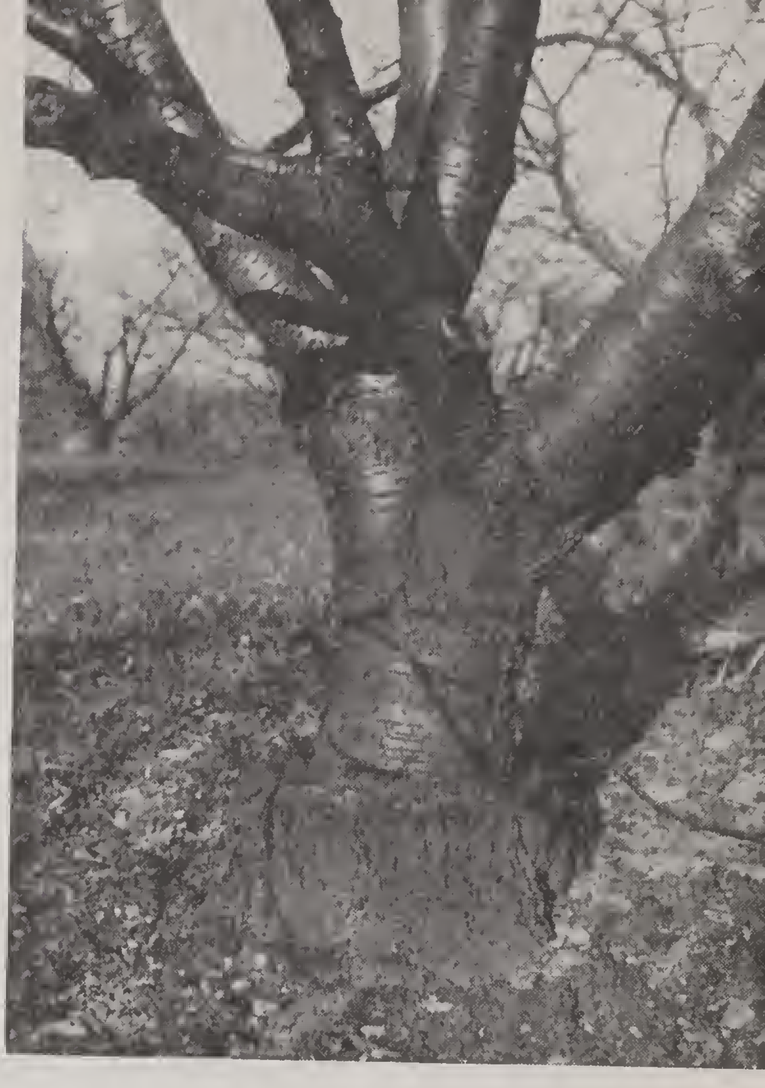


Figure 193. A vigorous Montmarency sour cherry tree growing an a Mazzard rootstack in western Pennsylvania. Note difference in vigor of root and top. Where extremely cald temperatures are nat likely to be a factar in the East, sour cherries on Mazzard stock are usually mare vigorous, higher yielders, and longer lived than those an Mahaleb stock.

The two rootstocks commonly used in propagating the cherry are the Mazzard and Mahaleb seedling cherries. The Mazzard is a semi-wild type of sweet cherry with small black more or less bitter fruits; it is native to Central and Southern Europe. Mazzard seed for rootstocks are obtained from Europe and from trees which have escaped cultivation in sections of the United States where the sweet cherry is grown. The Mahaleb variety is native in southwestern Europe and is probably more closely related to the sour cherry types than to the sweet types. The tree tends to be thick, bushy-topped, spreading, and small in size. Seeds for rootstocks are obtained from trees in southern Europe. Seedlings from standard commercial varieties of sweet cherries are sometimes used by nurserymen for rootstocks, but the trees are often less vigorous, less uniform, and less satisfactory than the true Mazzard. The sour and native "pin" or "bird" cherry seedlings are not considered satisfactory for rootstocks.

The Mazzard stock is used almost exclusively on the Pacific Coast as a stock for sweet cherries and to a considerable extent for other types. It produces trees which are somewhat larger and more productive than those grown on Mahaleb roots, though apparently the Mazzard stock is not so well suited to the heavier soils. In the eastern states, the Mahaleb stock is more common, especially as an understock for sour varieties. Probably the Mazzard stock is to be preferred for both sweet and sour varieties in eastern sections where winter temperatures are not extreme. Results obtained at the New York Agricultural Experiment Station have shown that the sweet, sour, and Duke cherries grown on Mazzard stock are larger, more vigorous, more productive, longer-lived, and show less mortality among young trees. In the East, however, it is clearly evident that the Mahaleb stock is hardier than the Mazzard, and in regions where conditions of extreme temperature are likely to occur, the Mahaleb stock is recommended.

In Utah, Coe has shown that the Mahaleb stocks are better than Mazzard for commercial use with sweet cherries in the typically porous gravelly orchard soils of Utah. Trees on Mahaleb stock proved to be much superior in vigor, size, hardiness, survival and yield as compared with the Mazzard stock. The Stockton Morello in Utah is suggested for trial for dwarf home garden trees and on the heavier soils, but is not recommended for commercial plantings.

RESISTANCE TO COLD

Sweet cherry trees in general are somewhat more resistant to cold than the average variety of Domestica plum. There is no great difference in cold resistance among varieties grown extensively in the United States. Windsor, Governor Wood, and Yellow Spanish are more resistant than the average sweet cherry. Lyon has shown the most resistance, but it is a minor variety. Blossoms of the sweet cherry open somewhat earlier than the peach and, therefore, are more likely to be killed by spring frosts. The amount of cold required by the sweet cherry for breaking the rest period is slightly more than that for the average peach variety.

The sour cherry varieties, except for the Russian varieties, are about as resistant to cold as the medium-hardy varieties of apples, such as the Northern Spy. Russian varieties of sour cherries may be as resistant as the McIntosh apple and, therefore, should be a good parent for hybridizing to extend the commercial sour cherry region further north.

If growth of the sour cherry tree has ceased relatively early in the growing season due to leaf spot disease, low nitrogen, or drought, the buds may be more tender to cold during the winter than peach flower buds. In orchards under good management, however, much less trouble from winter killing of fruit buds is experienced. English Morello has shown less bud killing due to cold than Montmorency or Early Richmond. In view of the fact that sour cherries ripen early in the season and that a short season is required for maturing the buds and wood, they can be grown at relatively high latitudes, provided large bodies of water are available for moderating temperature during extremely cold nights.

PLANTING RECOMMENDATIONS

In view of previous statements on susceptibility of cherries to frost, it is apparent that a planting site with good air drainage or a site located near a large body of water is as important to the cherry as to the peach.

One-year nursery trees are frequently desired for sweet cherry varieties, whereas the two-year trees are preferred for the sour and Duke varieties. Fall planting is recommended in the Pacific Coast states and in the central and southern sections of the Middlewest and East. Fall planting in these regions usually results in more growth the first season and a more nearly perfect stand of trees. Spring planting is preferable in most regions in the northern states, because fall-planted trees are often subject to root killing by cold. Root freezing is apparently responsible for most of the difficulty in these regions rather than top freezing. There are some areas in the North, however, where fall-planted trees are successful because of protection from snow which falls early and remains late. However, if the trees for these areas were stripped of their leaves in the nursery in order to meet the delivery date, the tops may undergo severe cold injury the first winter.

Spring-planted cherry trees should be set as early as possible on fall-plowed ground. Delay in spring planting of cherry trees is probably responsible for the loss of more cherry trees the first season than all other factors put together. This may be due to the fact that cherry buds open relatively early and that evidently the cherry roots are a little slow in becoming established. This results in a greater demand for water by the tops than the roots can supply. Thence, the opening buds dry, the wood and bark shrivel, and the tree soon dies. This is one of the main reasons why fall planting is desirable in those sections where winter killing of the roots is not a factor.

Special care should be exercised in handling cherry trees during transit, storage, and planting. Cherry buds are easily rubbed off in handling operations because they are large and stand out prominently from the shoots. Due to possible loss of buds in handling and to the fact that the cherry does not form adventitious buds readily, an unsatisfactory distribution of new branches around the trunk may frequently occur.

Gardner recommends a planting distance in Michigan of 15 by 15 feet for English Morello and similar dwarf-growing varieties; 20 by 20 feet for varieties such as Early Richmond, Montmorency, and Late Duke; and from 24 by 24 to 36 by 36 feet for sweet cherries, depending upon the characteristic size of the variety and the soil conditions.

PRUNING YOUNG CHERRY TREES

Sour cherry. If the trees are one-year whips, they should be cut off about 24 inches above the ground. A selection of the scaffolds can be made the following year. If the nursery trees are branched two-year-olds, about two or three well-spaced laterals should be selected around the leader, with the lowest scaffold limb about 15 inches above the ground on the southwest side of the tree or toward the prevailing winds (Figure 194). Heading-back cuts should be avoided on the branches left to form the head, because such practice has a definite stunting effect on sour cherries, particularly under Missouri conditions.

The sour cherry tree naturally has an open spreading growth habit and for this reason many commercial trees are trained to the open-center system. However, the general experience with open-center sour cherry trees has been too many weak rotting crotches. In recent years, there has been a definite trend toward the modified-leader system of training sour cherries,

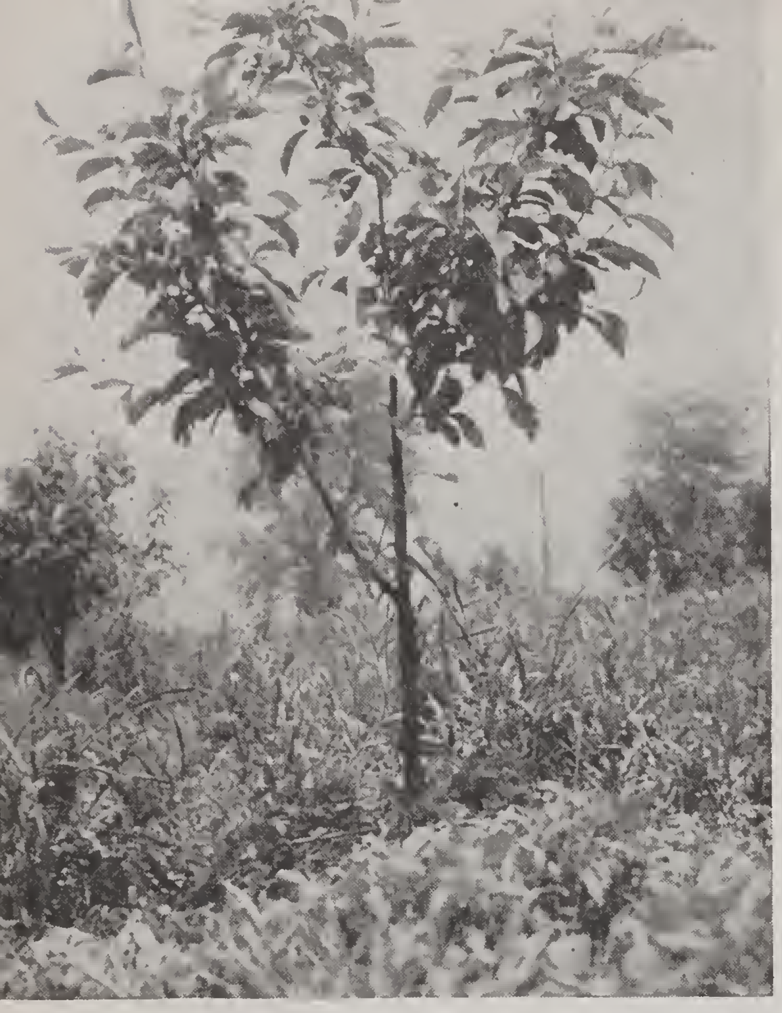
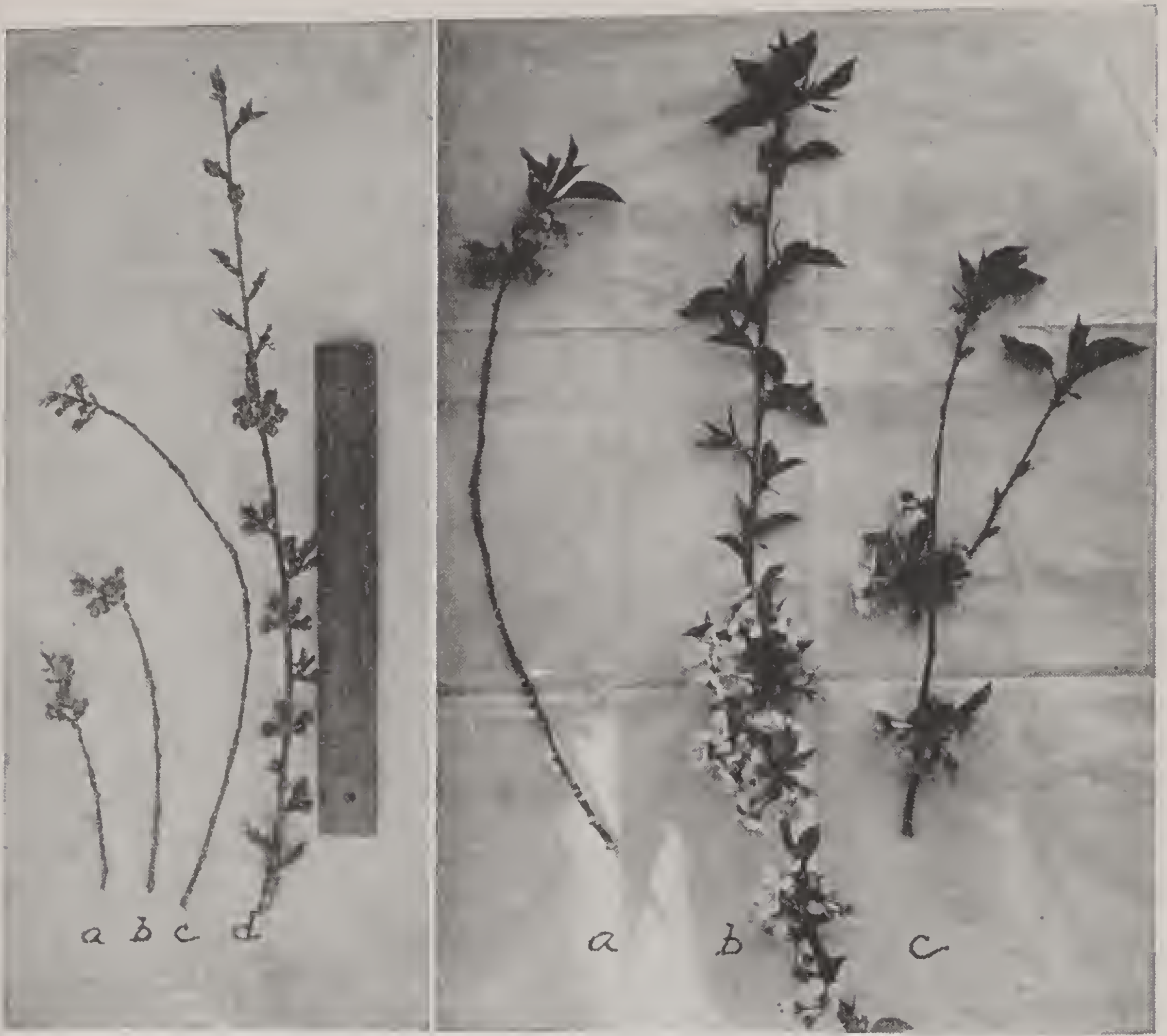


Figure 194. An excellent start in the framework of a sour cherry tree beginning its second season in the orchard. Note rye cover in background.

similar to that described for apples in Chapter IV. Although the modified-leader system of training trees requires somewhat more care and attention during the first four or five years in the orchard, it should add years to the life of the average sour cherry orchard.

About five or six scaffolds distributed over three or four feet of the trunk above the lowest branch gives a good strong framework. The leader is then modified by cutting it to an outward-growing lateral. In sour cherries, it is particularly important to give attention to the elimination of branches originating parallel with one another on the trunk. It is important, also, to avoid two scaffold limbs originating on the trunk at the same height. If two scaffolds are permitted to develop close together on the same side or opposite to each other on the trunk, later development of the leader and branches above may be considerably subdued and choked. The moderately vigorous sour cherry tends to develop numerous lateral shoots on the scaffold limbs and leader, and one must take special care not to prune these too heavily. It is particularly important with young cherries to prune as little as possible to attain the desired scaffold arrangement. Heavy pruning may delay full bearing several years.

Sweet cherries. Sweet cherry trees often come from the nursery as one-year whips which should be cut at a height of about 30 to 48 inches from the ground, depending upon the vigor of the tree. The deshooting system of training one-year whips is often practiced with the sweet cherry as described for the apple in Chapter IV. If allowed to grow without training, the sweet cherry will usually develop into a central-leader type of tree which becomes too high for economical production. It is important to prevent the leader and upper branches from being choked by opposite or closely placed scaffold limbs. Three or four later scaffolds with about 12 inches vertical distance between limbs, in addition to the leader which is modified to an outward-growing limb, will make a desirable framework for sweet cherry trees. The sweet cherry is usually susceptible to crotch splitting and, therefore, it is especially important to eliminate at an early stage any scaffolds with narrow-angled crotches. Wide-angled scaffolds not only develop a strong head but



H. B. Tukey, Michigan Agr. Exp. Sta.

Figure 195. (Left) Short annual growth (two to four inches) is associated with unproductive cherry trees (New York); long shoot growth (seven to twelve inches) is associated with productive trees. Long 2-year growth at D has numerous fruiting spurs on lower 2-year wood; upper 1-year wood has mostly leaf buds which will form shoots and fruiting spurs the following year. The three weak terminal growths of A, B, and C are from 4 to 6 years old and have produced only 2- to 4-inch shoot growth each year. Note lack of spurs, due to practically all buds being fruit buds each year; such wood has low productive capacity. (Right) Terminal growths of A and B show flowering and leaf development on wood similar to C and D, respectively, in left photo. Note at C that fruit buds on 1-year wood have been killed by low temperature, whereas those on spurs were not injured.

also reduce the hazards of winter injury and decay on the body of the tree.

Wayward limbs. On young cherry trees, frequently one finds a limb which has started to outgrow the others, and, if left alone, may result in a one-sided unsymmetrical top. This limb can be subordinated by heading it back more or less severely. However, if this vigorous side limb has gained considerable dominance over the other limbs, it may be advisable to gradually prune away the weak limbs and permit the new growths to replace them.

PRUNING THE BEARING CHERRY TREE

Sour cherry. Fruit buds of the sour cherry are produced laterally on one-year terminal growths and spurs (Figure 195). The terminal buds of shoots and spurs are leaf buds. If the terminal growth on sour cherries is less than about seven inches, nearly all lateral buds on such shoots will be fruit buds. After fruiting, this wood becomes largely bare. On the other hand, when terminal shoots are about seven inches or more in length, some of the lateral buds will be leaf buds from which spurs and lateral shoots develop. Sour cherries which are developing a good spur system have considerably more fruiting area than trees with a limited number of spurs. Furthermore, fruit buds on spurs are more resistant to winter freezing than those on shoots, as shown in Figure 195. It is important, therefore, to maintain moderately vigorous annual shoot growth by moderate to light pruning and principally by a good soil management program, as described later.

After a good framework has been established on the young cherry tree with as little pruning as possible, it is important to correct or eliminate any limbs which tend to develop at odd angles, crowd others, or grow across the center of the tree. Only sufficient pruning should be done to keep the tree from becoming dense and to lightly thin out through the top and sides for efficient light and spray penetration. Neglected dense trees result in considerable dying of spurs and limbs in the center and lower sections of the tree. Good air circulation through a tree is important in reducing the amount of brown rot developing shortly before and during harvest. Sour cherries, generally speaking, require relatively little pruning. In fact, in Michigan even light pruning over a period of years has been found to slightly reduce yields. This is because with the main variety, Montmorency, the fruit spurs are relatively short-lived. Also, regardless of the pruning treatment, the major portion of the crop is borne within a comparatively thin rim around the outside of the tree. The greater majority of the fruiting spurs are found on two- and three-year wood, with some on four- and five-year wood. After the first good crop of cherries on a spur, it seems to become less and less productive. Moderately-heavy pruning does not seem to invigorate these spurs; in fact, it has the opposite effect with sour cherries.

Sweet cherry. The fruiting habits of the sweet cherry are similar to those of the sour. Sweet cherry trees are probably pruned less than almost any other orchard species. The trees in general grow more or less upright and the main limbs form much less lateral growth as compared with sour cherries. It is important to head-back the main upright limbs when they attain a height of about 15 to 18 feet in order to keep the tree within a 20-foot maximum height, or preferably lower for economical management. The main upright and spreading limbs should be cut back to strong laterals to keep the tree within bounds. Mature sweet cherry trees probably require less pruning than mature sour cherry trees.

Sweet cherry trees tend to form long limbs with a whorl of side limbs located at relatively long intervals. Whorls of from three to five limbs should be reduced to two or three at the most the first dormant season after they have formed. It is difficult to correct such whorls if allowed to remain for two or three years until they have attained good size and begun to crowd each other.

Duke varieties resemble the sweet cherry in growth habits. The pruning system recommended for the sweet cherry is thus applicable to the Duke cherries.

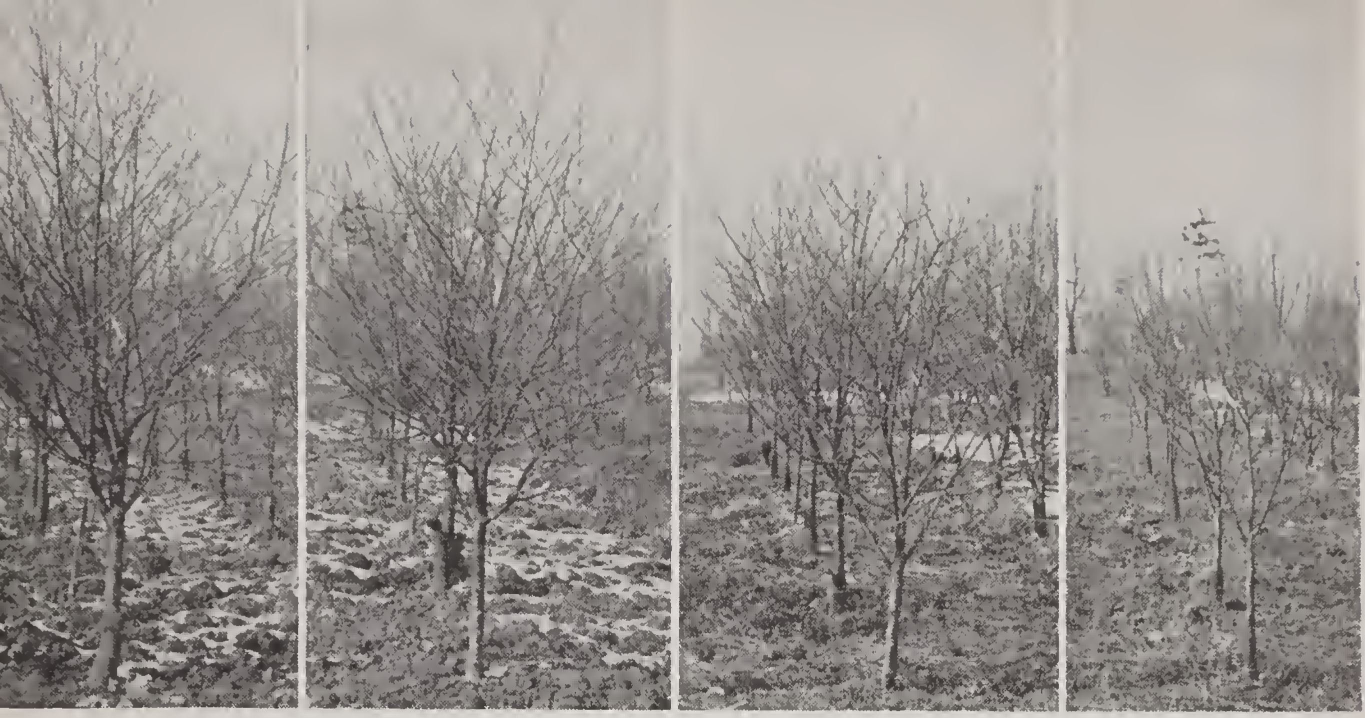
In order to obtain satisfactory healing of pruning wounds with both the sweet and sour cherry trees, special emphasis must be placed on making smooth flush cuts, avoiding ragged wounds and stubs. Cherry wounds naturally heal slowly and are very susceptible to wood-rotting fungi.

SOIL MANAGEMENT

Cherry trees are almost as responsive to nitrogen and clean cultivation as the peach. A system of shallow cultivation with cover crops, as described for peach trees in Chapter XIII, is generally recommended for both young and mature sweet and sour cherries. The cultivation consists of a shallow plowing or early disking followed by only a sufficient number of cultivations with a spike- or spring-tooth harrow to keep down the weeds. The early cultivation should either be done two or three weeks before blossoming or after the fruit has set. Cultivation during bloom apparently affects the root system and tends to reduce set. Cultivation should be done before bloom if a fast-growing cover crop such as rye is used; otherwise, the cover crop may compete heavily with the tree for water and nutrients at the critical fruit-setting period. A summer cover crop such as soybeans may or may not be sown before the winter cover. Cover crops frequently used in cherry orchards are millet, rye and vetch, oats, buckwheat, field peas, soybeans, amber sorghum, and Sudan grass. Rye grass has gained considerable attention as a winter cover in western Pennsylvania and New York.

A study of the effects of cultivation and nitrogen applications on young Montmorency trees is shown in Figure 196. These results are typical. On a moderately heavy soil in New York, it is apparent that sufficient nitrogen was released in cultivation to grow trees about the same size as those in sod receiving relatively heavy nitrogen applications. The average growth of trees in sod receiving nitrogen was more than twice as great as for trees without nitrogen. On the other hand, trees in cultivated plots with nitrogen applications were only about one-third larger than trees without nitrogen fertilization. Results in Michigan have shown that although cultivated trees may be delayed in bearing one to two years as compared with trees in sod, the subsequent higher yields of cultivated trees more than offset the delay in bearing. With cherries, it seems desirable to develop a full-size tree as soon as possible by encouraging moderately vigorous growth, after which less shoot growth is desired in order to induce and maintain heavy fruiting. In order to establish and maintain productivity in sour cherry trees, Gardner recommends:

"(1) For their first few years in the orchard, the trees should be so grown that their shoot growth averages 12 to 24 inches in length. While making



A. J. Heinicke, Cornell University

Figure 196. Montmorency sour cherry trees respond well to cultivation and nitrogen. The two left rows are under cultivation and the two right rows are in sod. The first row and the third row were fertilized the previous three years with 900, 900, and 1800 pounds per acre of nitrate of soda, respectively. The second and fourth rows received no fertilizer. On cultivated plots, nitrated trees were one-third larger than unnitrated trees. On sod plots, fertilized trees were almost twice as large as unfertilized trees. Cherry trees on heavily nitrated sod plots were almost as large as unfertilized trees on cultivated plots.

such a vigorous growth, they bear little fruit but increase rapidly in size and develop a large bearing surface for later production.

"(2) Then, until they attain full size, they should be so grown that their shoot growth averages six to twelve inches in length. While making growth of this type, they bear heavily and gradually increase in productivity.

"(3) After attaining full size and productivity, they should be so grown that their shoot growth averages four to eight inches in length. This will provide for a practically indefinite maintenance of yields."

No attempt should be made to produce the above growth and fruiting conditions by pruning alone. In fact, pruning should play only a minor role, with most emphasis placed on soil management, particularly nitrogen fertilization. In the East, nitrogen applied on medium to heavy soils has been the only fertilizer showing response in cherry trees. However, in the lighter gravelly and sandy types of soils, a complete fertilizer may be needed. In general, young nonbearing trees of most sour varieties should make an annual shoot growth of 12 to 24 inches, whereas young nonbearing sweet varieties should make from 22 to 36 inches. Mature bearing sour and sweet varieties should make a new shoot growth of about seven to eight inches each year to maintain high production. Failure to obtain this growth is most often due to lack of sufficient nitrogen, although drought and certain types of winter injury may cause the same result. The uneven ripening of fruit is more likely due to inadequate leaf area to accommodate a heavy set than to too much nitrogen, as some growers surmise. Experimental evidence indicates that the more nitrogen added, up to the point where vegetative growth is excessive, the higher the yields and the more profitable the orchard. The rate of nitrogen applications for cherries is similar to that recommended for peaches in Chapter XIV.

It should not be implied from this discussion that clean cultivation is being unconditionally recommended for mature cherry trees. There is a definite trend in Michigan, Ohio, and some other eastern states toward the use of sod with mulching and heavy nitrogen fertilization. This system is giving excellent results, provided sufficient nitrogen is applied; it has the main advantage of checking soil erosion on sloping land.

The nitrogen requirement of sweet cherry trees is probably somewhat less than for the peach and sour cherry trees. On the West Coast, sour cherry trees apparently can obtain sufficient potassium from soils in which apple trees and some varieties of Domestica plums will show potassium deficiency. However, according to Chandler the sweet cherry trees, especially the old ones, are more apt to show zinc deficiency symptoms in semiarid districts of California than are other fruit trees.

Liming of cherry orchards appears questionable from the standpoint of the tree, although it may benefit the cover crop. Observations indicate that the cherry will survive about equally well in a somewhat acid as well as neutral soil.

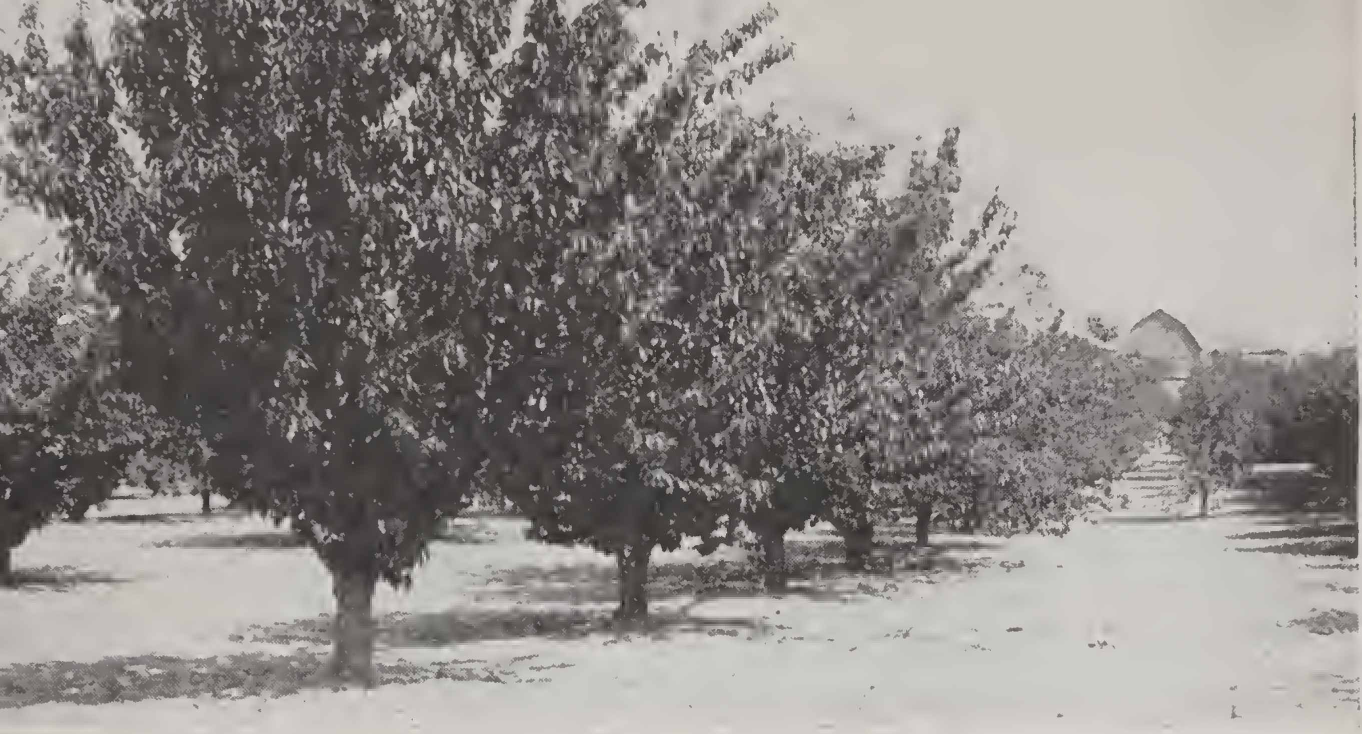
Irrigation is rarely practiced for sour cherry trees in the East because the fruits mature early in the season before the soil is apt to become deficient in moisture. However, if early dry periods occur, sour and sweet cherry fruits appear to be more sensitive to high transpiration and high daily water deficit than other deciduous fruits. This may be because the fruits are small and numerous and a higher percentage of the water within them can be removed by the leaves during hot dry periods of the day.

On the West Coast where sweet cherries are mainly grown, irrigation is a regular practice in some orchards, but it is probably practiced to a less extent than for most fruits for the same reasons given above. In the cool coastal areas of California, sweet cherries can be grown without irrigation in regions of about 15 inches of annual rainfall where other deciduous fruits ripening later in the season cannot be grown.

Hand thinning of sweet and sour cherry trees is not practiced because they ripen early in the season when soil moisture is usually adequate, and also because size of cherries is not as important in market sales and prices as it is for larger fruits, such as peaches and apples. Furthermore, Gardner has shown an apparent lack of correlation between size of fruit and size of crop on cherry trees.

HARVESTING CHERRIES

There is no standard degree of maturity for picking the cherry. Flavor and over-all colors as determined by sampling a few fruits of each variety, furnish the best guides for time to harvest. Cherries, like peaches, increase



(Top) F. P. Cullinan, U.S.D.A.

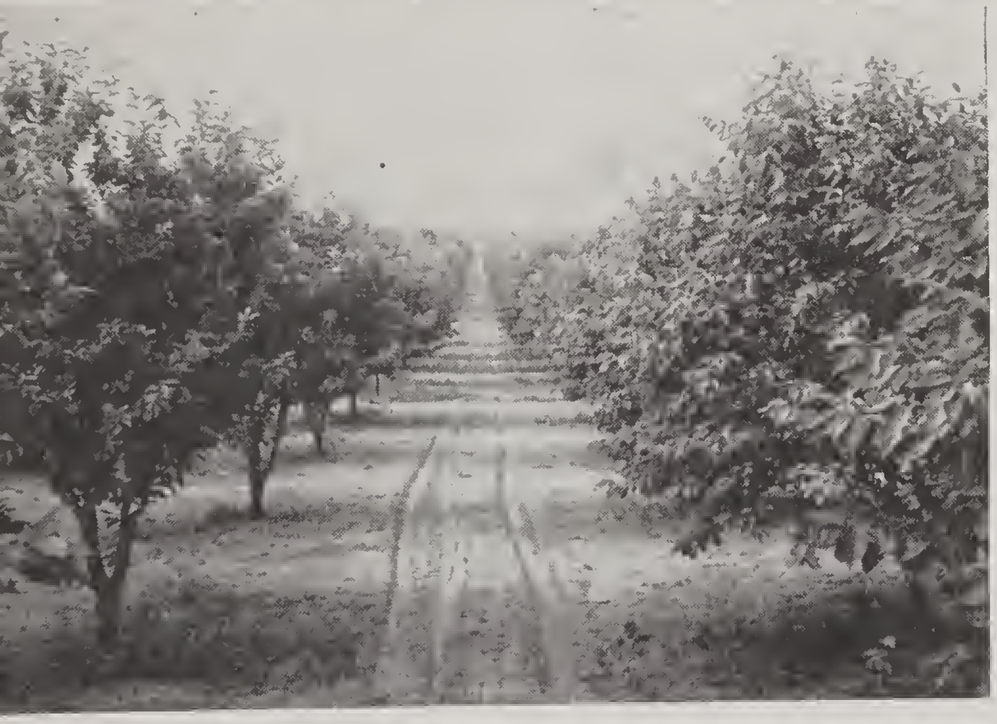


Figure 197. (Top) A row of 8-year Napoleon sweet cherry trees, showing excellent vigor under a system of clean cultivation with cover crops. (Bottom) A young Ohio sweet cherry orchard bearing its first crop near Lake Erie. The coarse sandy loam soil is under a system of clean cultivation with a winter cover of rye.

in size until ripe and should be left on the tree as long as feasible to attain the maximum poundage per tree. With firm-fleshed sweet cherries, there is some tendency among growers to harvest early to obtain better prices. This practice, however, results in less flavor and color and smaller size. Furthermore, cherries picked before fully mature will not ripen off the tree; if picked half ripe, they remain half ripe. There is little or no loss from leaving the fruit on the tree for one or two weeks after full maturity, except in case of sweet cherry varieties that may be subject to cracking. Investigations have shown that the final increase in fruit size may be as much as 35 per cent from the time they might first be picked (although premature) until full maturity. Fully mature cherries are less subject to shrinkage in volume when canned than those picked early. In fact, there is actually little reason for early picking of cherries for the cannery.

The period for picking cherries may be shortened by hot dry weather during ripening. The soft-fleshed juicy varieties tend to mature and deteriorate more rapidly than the firm-fleshed varieties which generally provide a longer period for picking and handling. Of the sour cherries, English Morello will hang on the trees longer without deterioration than Montmorency or Early Richmond. Deterioration of the crop from brown rot at harvest can be prevented to a large extent by dusting with sulfur prior to picking, as recommended in Chapter XVII. Precooling as soon after harvest as possible is also important in reducing brown rot and general deterioration.

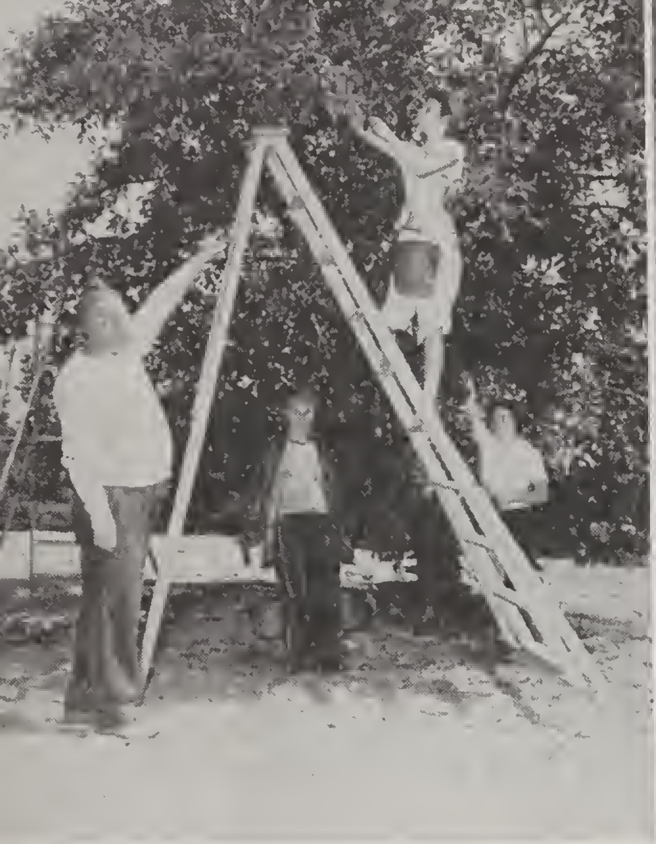
The grower of a large commercial cherry orchard must make plans several weeks ahead of harvest in order to obtain adequate sales containers, picking buckets, stepladders, lug boxes, and other equipment, and to engage sufficient cherry pickers to complete the job on time. High school children are frequently used in cherry picking because schools have usually closed for summer vacation by the time harvesting begins. Some larger growers in northern Ohio have made it a practice to engage high school teachers for over-all foremen of the picking crews. Before school closes, teachers engage a sufficient number of their students to complete the picking gangs. One supervisor can handle about 40 to 50 pickers and is employed on a day basis to assume full responsibility for the picking job. This releases the orchard manager for checking on sales and attending to the numerous other duties coincident with the disposal of a highly perishable crop.

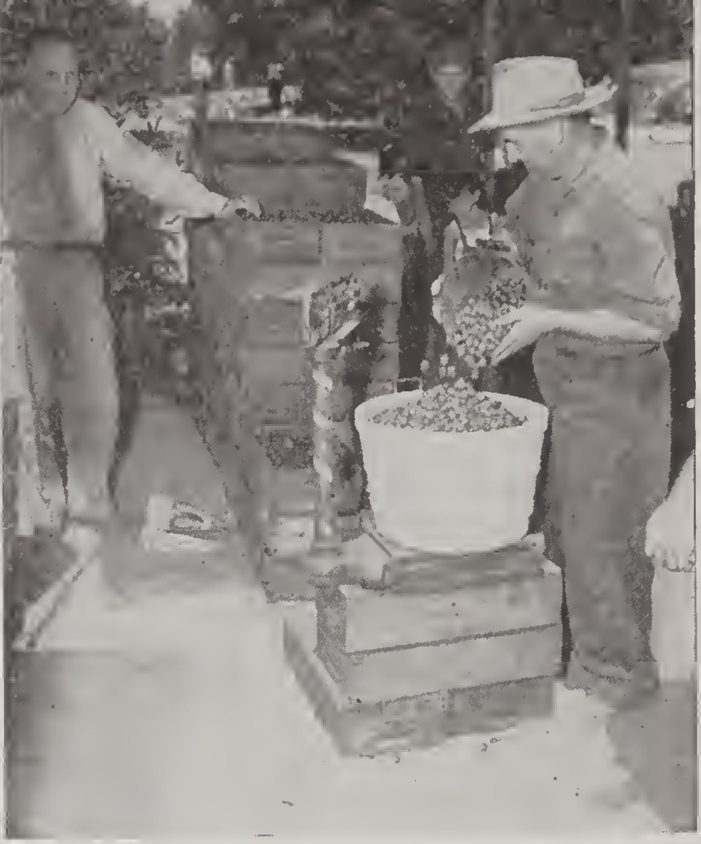
The following suggestions may be useful in executing the cherry harvesting program:

1. Assemble sufficient pickers to cover the job in about 10 to 14 days. This usually requires at least two good experienced pickers (or eight to ten children) per acre if the orchard consists of a single variety of full-sized heavily loaded trees such as Montmorency. About twice that number may be needed for some sweet varieties with a shorter harvesting season. If there are several varieties ripening in succession, the number of pickers needed may be less. One picker can strip about 300 to 400 pounds per day on heavily loaded trees. One to two cents per pound is an average wage for stripping in normal times.

2. Establish central headquarters in the orchard, using a portable shelter if possible (Figure 198), which can be kept near the picking crew. Tables with flexible canvas tops about 30 to 36 inches wide are often used for sorting cherries for fancy packs. Fruit is sometimes placed in retail packages during picking but this is not recommended for sweet or Duke cherries. Such a practice may be satisfactory where the crop is of uniform high grade and is intended for local markets.

3. Picking buckets commonly used are of the wide-mouthed type, holding six to eight quarts. A wire hook is convenient for holding the picking bucket on a hip belt, limb, or ladder rung. When filled, buckets are emptied in shallow lug boxes (Figure 198).





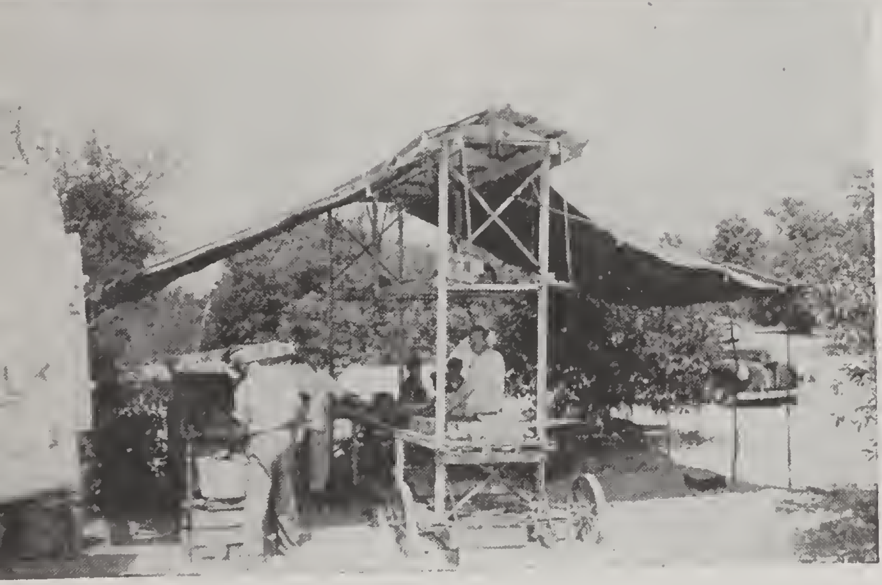


Figure 198. (Top left) Harvesting sour cherries in July in northern Ohio, using school children under the supervision of a high school instructor. Note harvesting equipment. (Top right) Sour cherries are weighed and sent to Cleveland canneries, restaurants, and bakeries in 20-pound returnable lugs by refrigerated milk truck shown in bottom photo. (Bottom) Portable sorting and assembly shed which can be moved through orchard with picking crew.

4. Most growers "strip" the trees for canning or freezing purposes when fruits on the lower third of trees are almost full-ripe.

5. Pick without stems if the fruit is to be used immediately in canning or frozen packs. If stems are left intact, pickers should be cautioned against removing spurs. Pick when the fruit is dry and place it in the shade.

6. Duties of the superintendent are (a) assemble and transport pickers in the grower's truck; (b) keep pickers progressing across the orchard in systematic fashion, cleaning up a certain number of rows as they go; (c) move ladders for girls and younger children only after they have thoroughly picked their section of the tree; and (d) start children at the beginning of the day on trees they left unfinished the previous day.

7. Only reliable experienced pickers are paid by the day. The greater majority of the pickers are paid by piece work.

8. In picking for fancy fresh-market packs, grasp the stems and *not* the fruit, using care not to break off the spurs or buds. Growers of cherries for high-class trade sometimes prefer that the picker use shears to clip the stems. Fancy sweet cherries must be handled with the utmost care since they readily show the effects of bruising.

9. The quantity of cherries picked for fancy packs in a day varies from 100 to 300 pounds per person. Probably 200 pounds is an average when the trees are carrying good crops.

10. For canning purposes only one picking is made as a rule. For fresh market, several pickings may be necessary, the number depending upon the variety and the weather conditions during harvest.

11. An added inducement to experienced pickers is the provision of special bunks and living facilities for floating labor. Some growers have constructed special concrete block-tile tourist cabins used for labor during the picking season and for tourist-trade at other seasons.

Robins, starlings, and other birds may become a serious problem in cherry orchards during the harvest season. The birds often damage as many or more cherries than they eat. Recommended practices for a few backyard cherry trees has consisted of (1) planting a mulberry tree near-by whose fruits are more attractive to the birds than the cherries, (2) placing pieces of glistening tin or heavy tin foil in the trees to dangle and shift with the wind, (3) using a scarecrow, and (4) placing a cat in a cage in the center of the tree. If birds become a problem in large orchards, Cardinell suggests the use of an automatic acetylene exploder which may accommodate two to four acres of cherry orchard. The exploder is timed to explode once every four or five minutes with a charge resembling that of a 12-gauge shotgun. Over a period of two to three weeks during harvest, the birds do not seem to become accustomed to the exploders, fleeing the orchard after each explosion. Cost of operation of these exploders from early morning to late evening was considered very low in comparison with the savings effected.

Packages. Over 95 per cent of the carlot shipments of fresh cherries come from California, Washington, Oregon, and Idaho. These cherries are largely shipped in boxes. There is considerable confusion as to the size of cherry boxes, many of which are not standard. This is due to the desire of the shippers to use distinctive packages and to pack a certain number of pounds per box. Also, cherries vary in weight from one season to another and from the first of harvest to the last, depending upon the sugar content. Because of the fact that sweet cherries have relatively high value per pound, the shipper must consistently pack close to the weight marked on the container in order not to lose profit through overweight.

The eastern flat which holds about eight pounds of fruit is used extensively and almost solely in California for early shipments. The Lambert lug, holding about 12 pounds, is used in Washington and is popular in California. The Los Angeles lug which holds 27 pounds with cleats and 24

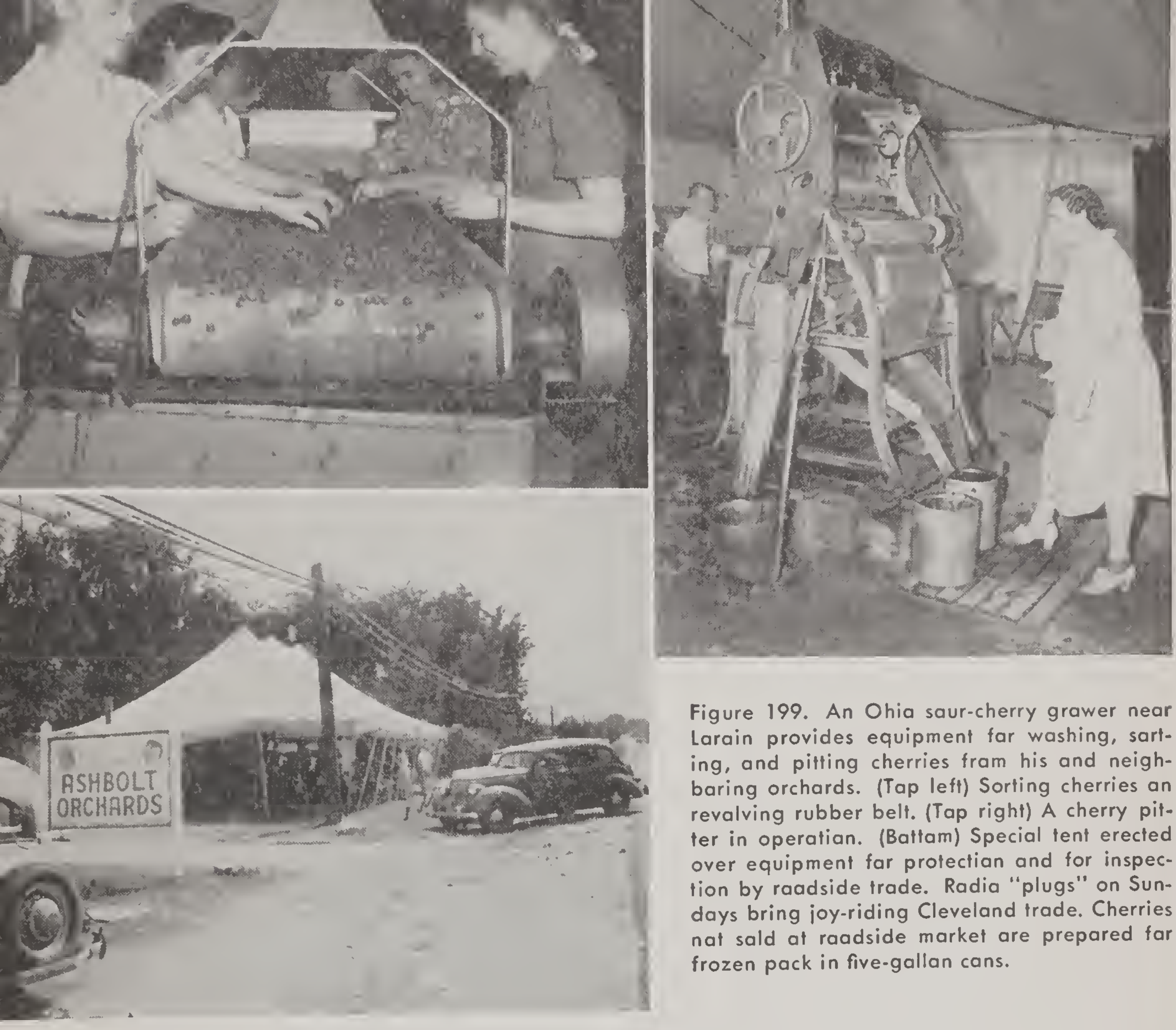


Figure 199. An Ohio sour-cherry grower near Lorain provides equipment for washing, sorting, and pitting cherries from his and neighboring orchards. (Top left) Sorting cherries on revolving rubber belt. (Top right) A cherry pitter in operation. (Bottom) Special tent erected over equipment for protection and for inspection by roadside trade. Radio "plugs" on Sundays bring joy-riding Cleveland trade. Cherries not sold at roadside market are prepared for frozen pack in five-gallon cans.

pounds without cleats is used mainly for local shipments in California. In Washington, the Los Angeles lug is used without cleats and frequently packed with 20 pounds net of cherries. This package is also used in Oregon and is second in popularity to the northwest fancy box in which cherries are row-packed throughout. Many western shipments in recent years have consisted of the Campbell and Calex lugs, which hold about 15 pounds of cherries. The Campbell lug is usually single or double faced and filled, whereas the Calex lug is frequently used for loose cherries. The Calex lug has shown considerable variation among different shippers as to size. A 12-pint crate is used for cherries in the Santa Clara Valley of California.

In eastern states, mainly Michigan and Wisconsin, cherries are packed either in 16-quart Hallock or American berry crates. In New Jersey, New York, Pennsylvania, and Maryland, the 32-quart American crate is used in addition to 4- and 12-quart Climax baskets. Cherries are usually delivered to canneries in 20- to 30-pound lug boxes. The quart and pint containers and crates are used for soft-fleshed cherries, whereas the larger boxes are used for firm-fleshed sweet cherries, such as Lambert, Bing, Schmidt, and Black Republican. In the box-packed fruit, each specimen of the face layer is placed on its flat side and in a neat straight or diagonal design. The stems are inclined downward so that they are not readily apparent when the box is opened.

Grading. Cherries for fancy packs, canning, or freezing are graded from canvas trays or a moving belt (Figure 199). Fruits are removed which show evidence of curculio, fruit fly (maggot), brown rot, or cracking. Cherries showing wind bruising (brown discoloration of the skin) are also eliminated. All cherries that pass this inspection are put in Grade 1. Larger cherries may bring a premium. Sweet cherries for fresh trade are frequently sorted into several grades according to size after the blemished fruits have been removed. Highest prices are usually obtained for the largest fruits.

Storage. Cherries are not adapted to long storage, but may be held for a few days while the market is being cleared of an excess supply. They should be stored at a temperature as near 32° F. as possible in order to minimize wilting and loss from brown rot. It is preferable to grade and pack the cherries before storing. Cherries to be shipped to distant markets should be precooled, if possible, before shipping in refrigerated cars (Chapter XIII). Firm-fleshed sweet cherries may be shipped for a distance of a thousand miles under conditions of nonrefrigerated express or parcel post. Soft-fleshed cherries could hardly be shipped successfully a quarter of that distance. Some growers truck soft-fleshed cherries 100 to 300 miles over good roads, and firm-fleshed sweet cherries as much as 350 miles during the night and early morning hours in order to save cost of a refrigerator car and cartage at destination.

According to Gerhardt and Ryall, an addition of 25 per cent carbon dioxide to the storage air at 45° F. has shown better results in retaining firmness, brightness, freshness, and freedom from decay in sweet cherries than with ordinary storage conditions at 32° F.

MARKETING

The largest percentage of both the sweet and sour cherries reach the consumer either directly or indirectly through the tin can, the frozen pack, or the glass jar. The relative amount of sweet and sour cherries sold fresh, canned, frozen, or brined may vary somewhat from year to year. Table 19 gives the relative importance of these four outlets for cherries. Only a small amount of the cherry crop is candied or used for juice, wine, and preserves.

Of the total sweet cherry crop of 94,820 tons sold in 1945, about 45 per cent was sold fresh, 22 per cent canned, 6 per cent frozen,[1] and 25 per cent brined for maraschinos. In a total of 41,890 tons[2] of sour cherries sold, 16 per cent was sold fresh, 60 per cent canned, 20 per cent frozen, and less than 1 per cent brined.[3] Thus, a large part of both the sweet and sour cherry crop is processed and under these conditions, the cherry grower's marketing

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[1] Freezing of sweet cherries started about 1943.

[2] A low-crop year; sour cherry crop is irregular due to variable weather conditions in the East.

[3] Brining of sour cherries started in 1943.

TABLE 19

Utilization of Sweet and Sour Cherries in the United States in 1945[1]

(*In tons*)

State	Cherries Sold	Utilization of Sales				
		Fresh Sales	Processed			
			Canned	*Frozen*	*Brined*	*Other*[2]
Sweet Varieties						
N. Y.	2,040	1,040	....	....	1,000	...
Pa. & Ohio	660	340	20	250	50	..
Mich.	300	150	....	....	150	...
Wash.	29,760	16,400	6,530	940	5,590	300
Ore.	17,900	4,900	5,900	900	5,800	400
Calif.	37,700[3]	16,000	8,200	2,800	10,700	...
Other States[4]	6,460	3,840	930	1,170	520	
11 States	94,820	42,670	21,580	6,060	23,810	700
Sour Varieties						
N. Y.	6,900	1,100	2,510	3,290	...	...
Pa. & Ohio	4,690	1,140	2,670	640	180	60
Mich.	13,250	1,650	10,100	1,400	100	..
Wis.	6,800	730	4,880	1,180	10	...
Wash.	3,810	870	1,570	640	...	730
Oreg.	1,800	300	1,200	280	20	...
Other States[4]	4,640	1,090	2,510	1,040	..	.
11 States	41,890	6,880	25,440	8,470	310	790

[1] Adapted from, "Fruits (noncitrus)—Production and Utilization, 1934–45," U. S. Dept. of Agr., Bur. of Agr. Econ. Report (Processed). June, 1946.

[2] Includes fruit used for juice, wine, preserves, and candied cherries.

[3] California "fresh sales": shipped out of State, 9,800 tons; for fresh use intrastate, 6,200 tons.

[4] Includes Montana, Idaho, Colorado, and Utah.

problem is comparatively simple. Although he may not obtain a cannery or frozen-pack price which he considers entirely satisfactory, the crop is usually contracted for a definite figure before harvesting begins. The final problem of finding a consumer for the fruit rests entirely with the canner and not the producer.

If fresh shipments are made to distant points, the cherry grower must follow trade channels similar to those described for apples in Chapter XI. Due to the perishable nature of cherries, the major portion is shipped by express.

In big centers of consumption such as Cleveland and Detroit, a large amount of cherries sold fresh may be trucked in to dealers and sold on a cash basis. Restaurants use a sizable percentage of these shipments in cherry pies and cobblers during the fresh cherry season. Some of these shipments also may be sold to hucksters who peddle the fruit for small sales. Roadside markets offer a good outlet for fresh cherries. In fact, cherries come at a time in the season when the roadside markets, restaurants, and retail stores are not well supplied with other fruit. In order to cater to this type of trade, however, the medium to small cherry grower should plant a considerable number of varieties, beginning the season with an extra early variety, such as Early Purple or Burbank and closing it with Late Duke or another equally late and equally good variety. Good roadside market trade will depend upon high-quality cherries packaged attractively.

Cherries for the most part are consumed in those areas of the country where they are grown. This is probably because people in these areas have acquired the cherry-eating habit. There is room for expansion of sales of cherries in areas of the country where the cherry-eating habit is not so well established.

COST OF GROWING CHERRIES

The amount of profit which a grower can make from a cherry orchard will depend chiefly upon three factors: (1) yields, (2) production costs, and (3) current prices. Yields vary considerably from one area to another. Over a period of 30 years from 1910 to 1940, the average yield per acre for Washington, Oregon, and California, was estimated to be 2200 pounds. In the eastern states, where most of the trees are of the sour varieties, the average production is about 1200 pounds per acre. These figures for both the East and West include comparatively young-bearing trees as well as those in full-bearing, and likewise, those with poor care as well as the better orchards. Experienced cherry growers will recognize these figures as being very low and not representative of good commercial orchards. In order to arrive at these averages, however, there are some orchards obviously bearing less than the average. Good commercial orchards in Michigan begin to bear at five to six years of age and reach 6000 to 10,000 pounds per acre per year over a ten-year period, beginning with the eighth or ninth year at which time, the orchard usually reaches full production. The trees continue at this production until about 20 to 22 years of age, after which they begin to decline more or less rapidly as the case may be. There are authentic Montmorency yields in Michigan of 22,000 pounds per acre. These figures give some idea of what a Montmorency orchard can do when conditions are reasonably favorable and good cultural practices are applied. One of the better English Morello orchards in Michigan, planted 16½ by 16½ feet, 200 trees per acre, yielded as much as 16,319 pounds on 1¼ acres. English Morello is naturally a lighter bearer than Montmorency.

English Morello trees in Michigan produced 1000 pounds when eight years old and from 5000 to 8000 by the thirteenth or fourteenth year. Sweet cherries produce 1000 pounds per acre at eight to nine years of age with an increase of from 7000 to 8000 when 14 years old. Duke varieties produce from between 1000 and 2000 pounds at from nine to ten years and increase to 5000 pounds per acre when 15 years of age.

TABLE 20

AVERAGE HOURS OF MAN LABOR REQUIRED BY OPERATIONS IN 69 SOUR CHERRY ORCHARDS IN MICHIGAN, 1943
(ADAPTED FROM WRIGHT AND JOHNSTON)

OPERATION	HOURS PER ACRE
Growing	
Pruning and brush removal	17.3
Spreading fertilizer	2.1
Spraying	11.7
Cultivating	4.8
Other	3.7
Total	39.6
Harvesting	
Picking	64.4
Total to grow and pick 1102-pound yield	104.0
Total to grow and pick 1937-pound yield	162.7

The expected commercially productive life of sour cherry trees in New York is estimated at 30 to 40 years and for sweet cherries at 50 to 60 years. In Michigan these estimates are as follows: Montmorency, 30 years; English Morello, 25 years; and Sweet and Duke cherries, 40 years. The commercially productive life of a cherry tree may vary widely according to cultural practices, insects and diseases, regions, and other factors affecting the vigor of the tree.

In Michigan, it was found that the Montmorency variety was definitely the better as a money maker. The English Morello gave satisfactory results in some regions, whereas in other regions it did not prove profitable. Early Richmond and Louis Phillipe were doubtful for extensive planting. Sweet cherries such as Windsor, Schmidt, and Bing and the Duke varieties gave only fair results, and should be grown as a supplementary crop, rather than a major enterprise of the grower. Because of fruit cracking, the Lambert variety proved to be a liability.

The itemized man hours per acre for growing and harvesting sour cherries in Michigan in 1943 are given in Table 20. Picking required the most labor, followed in order by pruning and brush removal, and spraying. About 64 man hours per acre were required to grow and harvest a 1102-pound yield, or about 163 man-hours for a one-ton yield. This indicates that about 200 man-hours would be required to grow and harvest a one and a half-ton yield.

Itemized costs of growing sour cherries in these same Michigan orchards in 1943 are given in Table 21. While costs vary considerably from year to year, one can gain from these data an idea of the relative importance of the different operations. Total cost per pound at the average low yield of 1102 pounds per acre was 13.1 cents; cost per pound was estimated at about seven cents per pound for a 3000-pound yield.

TABLE 21

Sour Cherry Costs by Production in 69 Michigan Orchards, 1943

Item	Costs per Acre		Costs per Pound (1102 Pounds per Acre)
	Amount	*Value*	
Overhead Costs, total		$ 51.66	4.6 cents
Depreciation in tree value		13.36	1.2
Interest on orchard at 5%		15.19	1.4
Share of general farm expense		12.56	1.1
Management charge		10.55	.9
Growing Costs, total		$ 57.70	5.2
Man labor	40 hrs.	18.95	1.7
Power and equipment use, total		22.04	2.0
Tractor	13 hrs.	12.22	1.2
Sprayer	6 hrs.	4.37	.4
Truck	N. A.	2.46	.2
Other equipment	N. A.	1.49	.1
Horse work	6 hrs.	1.50	.1
Materials used, total		16.71	1.5
Spray	N. A.	8.53	.8
Fertilizer	N. A.	6.33	.6
Other[1]	N. A.	1.85	.1
Harvesting Costs, total		$ 36.66	3.3
Picking	64 hrs.	33.95	3.1
Hauling	N. A.	2.71	.2
Total through harvesting		$146.02	13.1 cents

[1] Cover crop and miscellaneous items.
"N. A." means not available.

The production costs for sweet cherries in Washington in 1927–28 may be more representative of actual costs in 1950–55 than those during World War II. Such costs were a little over three to four cents per pound. The harvesting and packing costs of two and a half cents raised the total cost to approximately six and a half to seven and a half cents per pound. In eastern states, in Michigan for example, under good management conditions, sweet cherries should yield 8000 pounds per acre at a cost of about 1.76 cents per pound. The cost of harvesting and packing sweet cherries in Michigan in what might be termed "normal" times is approximately four to four and a half cents per pound. Sour cherries under good growing and management conditions in the East should produce from 10,000 to 15,000 pounds per acre at a production cost of 1.32 and 1.06 cents per pound, respectively. Harvesting costs for sour cherries for commercial canning is between one and two cents per pound.

Prices received for cherries fluctuate with supply and demand. Prices paid by one eastern cannery for Early Richmond and Montmorency cherries varied between two and eleven cents per pound from 1916 to 1944, with an average of approximately five cents. Prices received for sweet cherries on the West

Coast during the same period were about seven cents per pound. Higher prices may be obtained for early and particularly fancy products sold in small packages. However, the extra handling charges for the small packages usually absorb much of the difference so that in the end, the net profit obtained for a fancy packed product is not much more than that obtained for the product at the packing house or delivered to a cannery.

In order to make a profit, it is usually necessary for the yield of cherries to exceed 2500 to 3000 pounds per acre. Cherry orchards producing as little as 1200 pounds per acre are unquestionably a losing proposition, except perhaps during war periods when there is great need for food. Substantial profits can be realized from Montmorency orchards only where production costs per pound can be kept low by obtaining yields well over a general average of 50 pounds per tree.

In Michigan, Gardner states: "Indeed, it may be questioned if the producer of any other kind of fruit has within his ability to obtain greater net profit than the cherry grower. This is far from stating the profits as certain. Probably as large a percentage of cherry growers fail to make expenses as is true with most other fruits. Nevertheless, the possibility of a profitable industry exists where soil and climatic conditions are favorable for heavy and regular yields and where good marketing facilities are available; and this may become a certainty where cultural methods are employed that promote a vigorous growth and provide protection from injurious insects and diseases."

Review Questions

1. What are the leading states in commercial sour cherry and sweet cherry production? Where are the cherry orchards concentrated in these states?
2. Why has cherry production increased in the northern states and in California in recent years?
3. Why has the cherry variety list undergone relatively little change in recent years?
4. What is a Duke cherry?
5. List 2 important varieties of sour, sweet, and Duke cherries.
6. What are the climatic and soil requirements of sour and sweet cherries?
7. What are the pollination requirements of the sweet and Duke cherries?
8. Are sour cherry varieties used for cross-pollination of sweet and Duke cherries?
9. What two rootstocks are frequently used for cherries? What are the respective merits?
10. What is the relative resistance to cold of commercial varieties of sweet and sour cherries as compared with the peach?
11. What system of training the trees is recommended for sweet and sour cherries?
12. With regard to other deciduous fruits, what is the relative amount of pruning recommended for cherries?
13. What is the approximate length of shoot growth desired in young and mature

sour cherry trees? Should the desired shoot growth be obtained by pruning, cultivation or nitrogen fertilization?

14. Describe a good soil management system for young and mature cherry trees on a medium sandy-loam soil.
15. Why is hand thinning not practiced with cherries?
16. When is the proper time to pick (*a*) sour cherries for canning, (*b*) sweet cherries for fancy pack?
17. What are the advantages of leaving cherries on the tree until fully ripe?
18. Under what conditions and how long should cherries be stored?
19. What is the approximate amount of sour and sweet cherries processed and sold fresh?
20. What are 3 factors influencing net returns in cherry growing?
21. What is an approximate yield one may expect from a well-managed orchard of sour, sweet, and Duke cherry trees in full bearing?
22. At about what year do sour cherries reach full production?
23. At what age under Michigan conditions do sour cherries begin to show a decline in production?

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CHAPTER XVII

Control of Insects and Disease

Because of favorable soil and climatic conditions, fruits are grown year after year in the same regions. Thus, there is a tendency for insects and diseases to build up in these regions and for certain species to develop increasing resistance to spray chemicals used against them. An example of this situation is the codling moth in Colorado which, according to Hough, has developed through natural selection a strain definitely more resistant to arsenical sprays than strains in the East. In order to intelligently and economically fight orchard pests, and to adjust the program to changing conditions, the fruit grower must have a thorough knowledge of spraying and dusting equipment, spray and dust materials, and modern methods of applying them. There is no other phase of fruit growing that changes more rapidly from year to year than spraying and dusting chemicals and machinery.

Although there are many key practices in successful fruit growing, spraying probably is the most important cultural practice. Between 20 and 40 per cent of the total cost of commercial production of tree fruits is devoted to insect and disease control. Without this expenditure of money and effort in spraying, the trees would be relatively short-lived and the fruit almost worthless. In previous chapters, it has been emphasized that the general public is becoming more critical of the fruit it buys. Buyers are no longer dependent on a few sources of supply and if the product is inferior, they turn to citrus, vegetables, or to other sources for their needs.

Spraying may be defined as the application of chemicals in liquid form to fruit plants as a preventative and combative measure against attacks by insects and diseases. Dusting is the application of chemicals in the form of dust for the same purposes. Although the grower may use other measures in combating insects and diseases, he relies mainly upon the spraying program for a large measure of the control.

Some pests make a more or less regular appearance year after year and occur in sufficient quantities to require standard control measures. Others, although well-known to most growers, are considered minor and seasonal because they may be destructive only under certain conditions.

Insects and diseases can be divided into groups, depending upon distinct characters of the organism and the type of injury it causes to the plant.

Types of insects. Insects may be grouped from a control standpoint on the basis of their mouth parts, namely, (1) chewing, (2) sucking, and (3) lapping.

The chewing insects possess hard mouth parts with which they bite off parts of the plant (Figure 200). Examples of chewing insects are the codling moth which feeds largely on the fruit, and the tent caterpillar which feeds on the leaves. Other examples are the white grub of the June beetle which feeds upon strawberry roots, the grape flea beetle which is destructive to grape leaves, and the plum curculio which attacks stone fruits and apples.

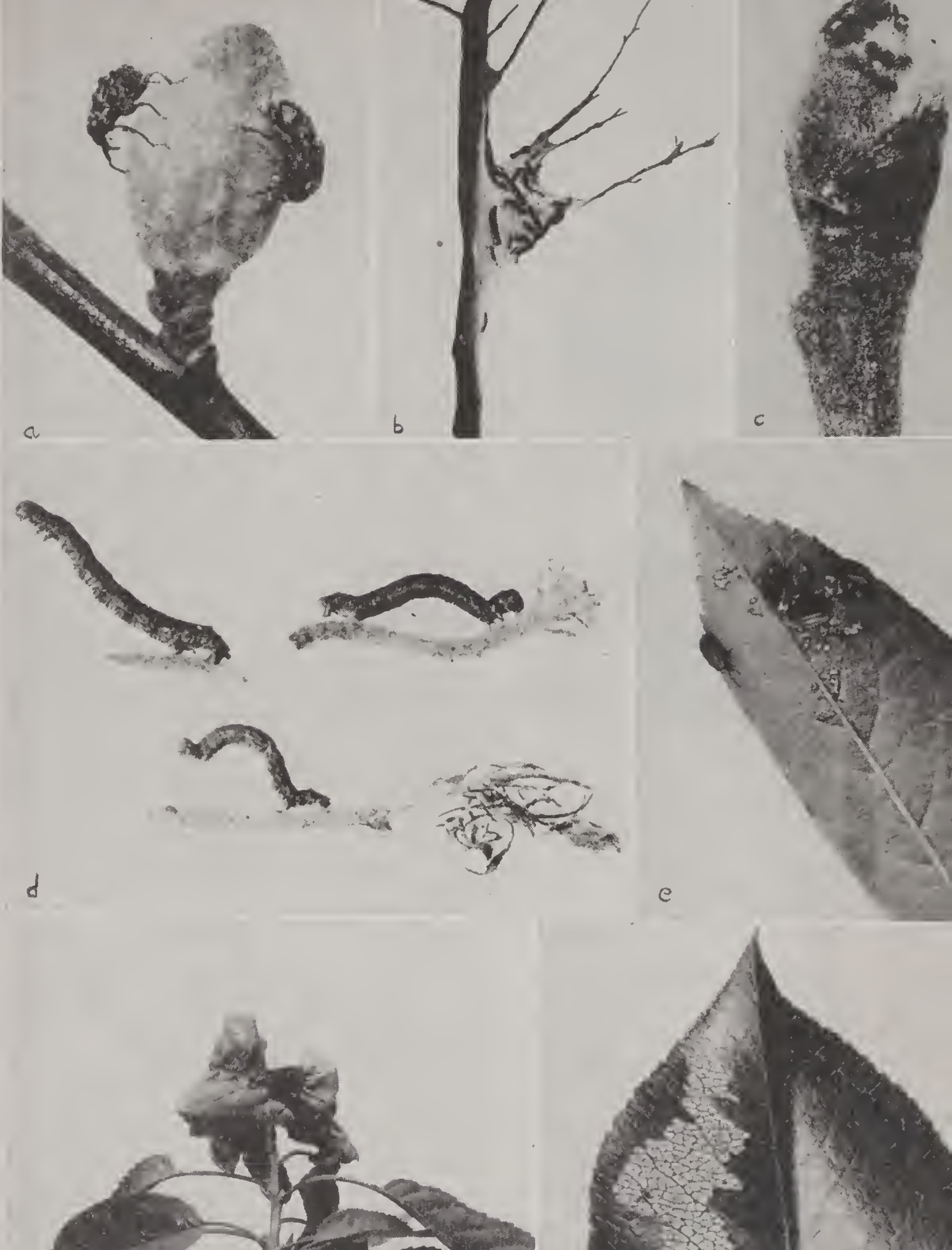
Sucking insects have tubelike mouth parts which they insert through the epidermis and tissues of the leaves, fruits and stems (Figure 200). The juices of the plant are thus withdrawn and digested. Examples of sucking insects are the aphids (plant lice), scales, red bugs, and leafhoppers.

The third group of insects possess lapping mouth parts with which they lap up liquids from the outer surfaces of the plant. Common fruit insects of this type are the cherry fruit fly and the adult fly of the apple maggot.

An insect may pass through several stages during its development (known as metamorphosis); as for example, egg, larva, pupa, and adult (Figure 201). An insect of this kind may have different types of mouth parts while passing through different stages. For example, in the larva stage, the cherry fruit fly has biting and chewing mouth parts, whereas the adult fly has lapping mouth parts. The same is true for the apple maggot. The aphid has sucking mouth parts from the time it is a small nymph to a full-grown adult.

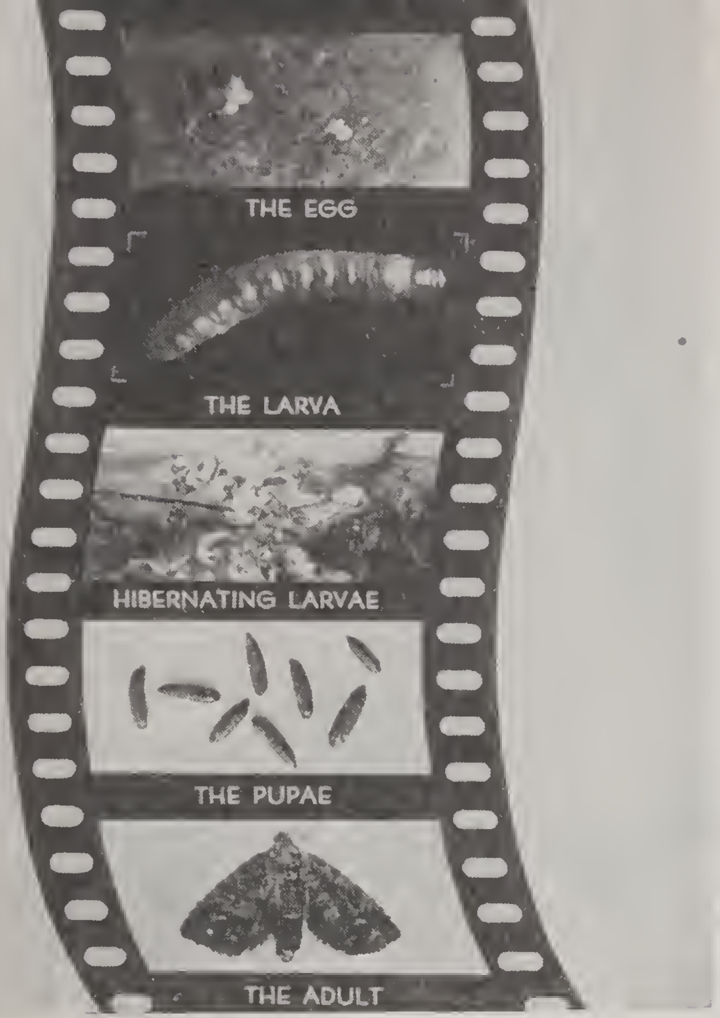
Types of diseases. A fruit disease may be caused by a fungus, bacteria, or virus (Figure 202), or it may be due to a physiological disorder. Most fruit diseases controlled by sprays or dusts are caused by fungi which are the lower plant forms lacking chlorophyll or green coloring matter found in higher plants. Fungi exist as parasites in or on the tissues of living plants. They are usually microscopic in size, although when vigorously present, they may be apparent to the naked eye. Examples are scab lesions on apple leaves and fruit, blue mold on apples in storage, and brown rot on peaches, plums, and cherries. Propagation of fungus diseases is by microscopic spores which may be transported by wind, light air currents, rain, insects, or other agents. Moist

Figure 200. Types of fruit insects: (*a*) plum curculio on peach, (*b*) tent caterpillar on apple, (*c*) rosy apple aphids on opening apple bud, (*d*) spring cankerworm on apple, (*e*) cherry leaf beetle on cherry, (*f*) black cherry aphis causing leaf curling on sweet cherry, and (*g*) pear slug on pear. Biting insects represented at *a*, *b*, *d*, *e*, and *g*. Sucking insects shown in *c* and *f*.



B. A. Porter, U.S.D.A.

surroundings are favorable for spore germination and fungus development under most conditions. In the spraying program, it is desirable to cover the fruit and foliage with spray or dust materials before rainy periods occur in order to prevent or inhibit spore germination and fungus growth.



Dow Chemical Co., Midland, Mich.

Figure 201. Four stages in the life cycle of the codling moth, a major apple insect. Eggs are laid on the leaf by adult moth; small larvae crawl to fruits, enter, gain full size; leave fruit, crawl down trunk or drop to ground, spin a cocoon; pupate; emerge as a moth; and start the life cycle again.

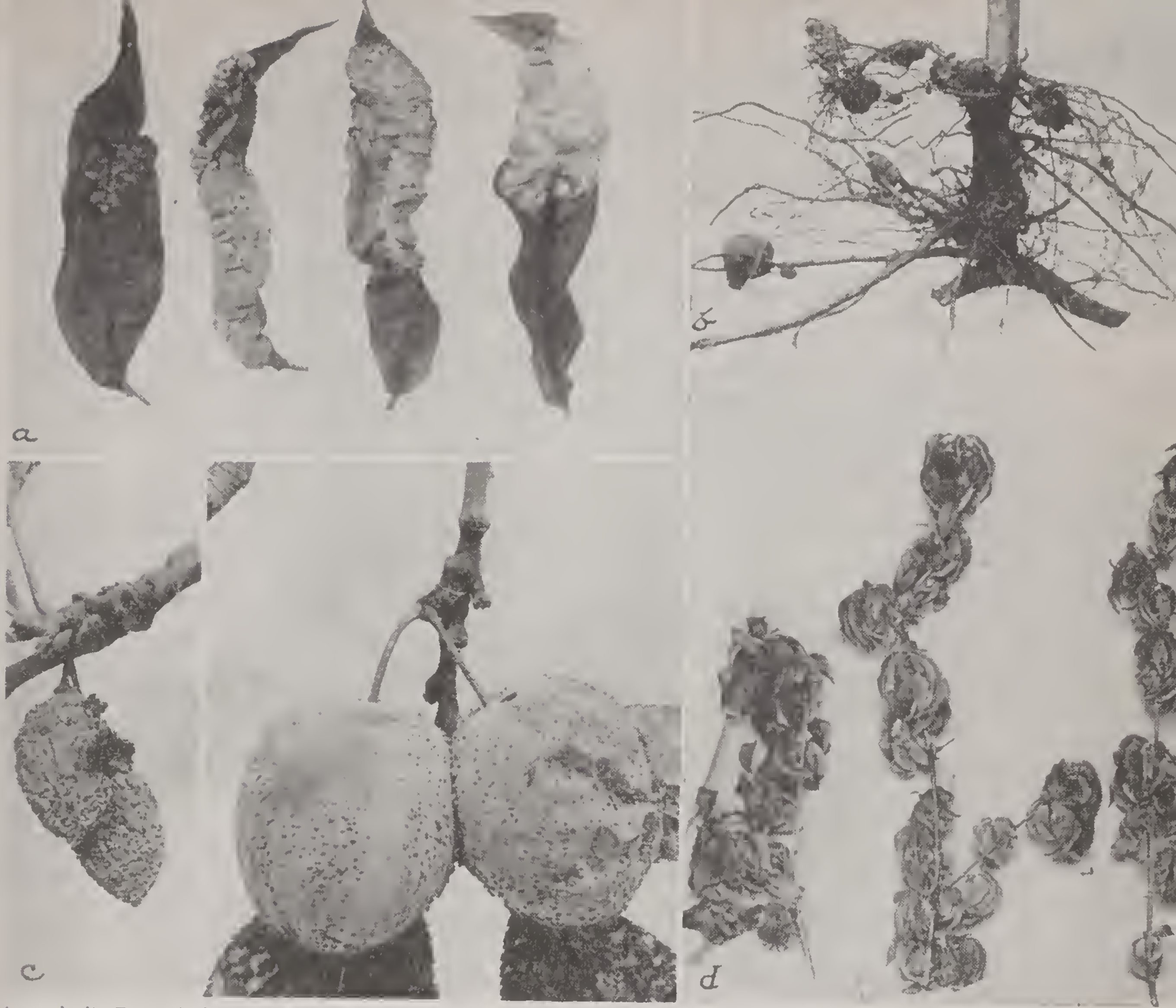
The bacterial diseases of fruits are difficult to control by spraying and are usually combatted by other means. Best example of a bacterial disease of fruit trees is fire blight of apples, pears, and quinces. Crown gall on nursery trees and brambles also is a common bacterial disease. The usual means of control of bacterial diseases is to rogue out and burn the plants or remove infected areas and thoroughly disinfect the pruning wounds.

Virus diseases are caused by ultra microscopic organisms which cannot be controlled by spraying. Plants affected are usually removed from the planting and destroyed by burning. Probably the best approach to combatting these diseases is by cross-breeding for development of resistant varieties. Examples of virus diseases are Peach Yellows, Streak disease of brambles, and Red Steele disease of strawberry roots. Raspberries and peaches are probably more affected by viruses than other fruits.

There are many physiological diseases which may be due to unbalanced nutrition, adverse weather conditions, poor stock-cion relationship, or other factors. Common examples are drought spot and bitter pit of apple fruits, black-end of pear fruits, cork in apple fruits caused by boron deficiency, and "little leaf" of many fruit trees caused by zinc deficiency.

THE ROLE OF EXPERIMENT STATIONS AND OTHER AGENCIES

The state and federal experiment stations play a vital role in the testing and search for new spray chemicals and better methods of applying them. The large spray machinery and spray chemical companies likewise play an indispensable role in this field. It is only through the co-operation between



(*a* and *d*) Donald Cation, Michigan State College, (*c*) Botany Dept., Purdue University, (*b*) F. G. Mundinger, New York Agr. Exp. Sta.

Figure 202. Typical fungus, bacterial, and virus diseases of fruits: (a) peach leaf curl (fungus), (b) crown gall on raspberry (bacterial), (c) brown rot on plum (fungus), and (d) red suture virus on peach.

these agencies, the fruit journals, and the growers themselves that outstanding progress has been made during the past half century.

At time of writing this chapter, the fruit industry is probably in the midst of the greatest transformation on methods of insect and disease control that has occurred in human history. In order to keep well informed on these rapidly changing methods, it is essential that the grower make frequent contacts with his local experiment station, and that he attend fruit meeings, subscribe to progressive fruit journals, and contact representatives of commercial companies as a safeguard and insurance in his orcharding program. The state experiment stations are particularly valuable because of their nonbiased recommendations based upon sound research.

The agricultural extension service in major fruit-growing states provides punctual and rapid communication to the growers on *when* and *what* to apply in the insect and disease control program. For example, in Ohio the extension service distributes spray information to the growers through two channels: (1) by letters, and (2) by radio broadcast. Spray schedules are mailed to interested growers before the spray season starts. The schedule contains information on concentrations of sprays, approximately when they should be applied, and the insects and diseases they are designed to control. The grower orders the necessary spray materials well in advance and overhauls his spray equipment to place it in good working condition. When the spray season begins, the growers are informed during critical periods exactly when (within hours) they should start spraying. Time of spraying is governed mainly by occurrence of rains, prevailing temperature conditions, and other factors which influence germination of disease spores and the emergence of codling moths.

The above information on "when to spray" is obtained through the co-operation of several key growers in important fruit regions throughout the state. During critical spray periods, these growers regularly send samples of leaves to the plant pathologists of the extension service, who examine them microscopically to ascertain the rate of development of scab spores. The key growers also maintain codling moth bait traps and report by telegram to the extension service the number of emerging codling moths. From this information and weather forecasts, the extension service prepares special radio broadcasts for specific fruit regions of the state. These are sent by telegram to the respective county agricultural agents who broadcast them over local radio stations at a specified and regular time. This information is available to all growers free of charge.

SPRAY MATERIALS

A chemical may be effective against one insect but ineffective against another, and it may be useless against diseases. On the other hand, there are some chemicals which control both insects and diseases. The grower must know the merits and weaknesses of the various materials, and in addition, their relative costs. New chemicals are being continually placed on the market and, again, the grower must decide if he should discard the old materials and adopt the new. He must base his decision upon known facts and not upon opinions, then proceed with judgment with as little risk as possible.

MATERIALS FOR INSECT CONTROL

Those substances which kill insects by their chemical action are known as *insecticides.* There are two general types: (1) stomach poisons, and (2) contact insecticides. Insects that obtain food by biting and chewing or by lapping are commonly controlled by stomach poisons. Insects that obtain food by sucking sap from the plant tissues are largely controlled by contact insecticides which kill by suffocating, burning, or paralyzing them. Contact insecticides also will control many chewing and lapping insects. A stomach poison is of little or no value for controlling sucking insects because they insert their mouth parts through the layer of poison and suck sap from beneath the epidermis. Insects with lapping mouth parts, however, can be controlled with a stomach poison since they obtain food from the outer surfaces of plant parts.

Fumigants or poison gases are occasionally used in fruit growing. An example is the control of the citrus mite by placing a tent over each tree and fumigating with calcium cyanide. This same chemical is used as a dust in California for controlling the grape leafhopper.

Stomach poisons. Commonly used stomach poisons in fruit plantings are the arsenates, cryolites (fluorine compounds), and nicotine bentonite (a contact insecticide).

The arsenates. The arsenates may be classified according to the following outline:

(A) Lead arsenates
    (1) Acid lead arsenate
        (*a*) Straight or standard lead arsenate
        (*b*) Suspended or deflocculated lead arsenate
        (*c*) Astringent lead arsenate
        (*d*) Platelet lead arsenate
    (2) Basic lead arsenate
(B) Calcium arsenate
(C) Magnesium arsenate
(D) Zinc arsenate

There are two kinds of lead arsenates used by fruit growers, namely, (1) the acid lead arsenates and (2) basic lead arsenate.

Lead arsenates. *Acid lead arsenate* is ordinarily called "lead arsenate" and is the kind referred to in literature on insect control unless specifically stated otherwise. The particles in acid lead arsenate are usually amorphous, but in recent years manufacturers have been producing a type in which the particles are flat or platelike crystals. Although the crystalline lead arsenate has become popular in the Pacific Northwest, investigators comparing the toxicity of crystalline and amorphous lead arsenates on codling moth have shown that the crystalline type is no more effective than the amorphous form.

Based on composition of the commercial product the acid lead arsenates may be grouped as follows: (*a*) straight or standard lead arsenate, (*b*) suspended or deflocculated lead arsenate, and (*c*) astringent lead arsenate.

(*a*) Straight lead arsenate (acid) is about 98 per cent or more arsenate of lead. Over 70 per cent of the lead arsenate used in the United States is of this type. Straight lead arsenate requires continuous agitation in the spray tank to prevent quick settling. The characteristic of "quick settling" is desirable in a spray chemical because upon coming in contact with the leaf surface, the arsenate of lead is quickly deposited on the leaves with relatively little loss in "runoff." As compared with other types of arsenate of lead, this type deposits relatively more arsenic oxide which is the active killing ingredient.

(*b*) Suspended arsenate of lead (acid) contains 96 per cent active ingredients with gum arabic and similar vegetable gums which keep arsenate of lead particles in suspension for a short time after agitation ceases. Hence, this type of arsenate of lead is adapted to small home garden sprayers which provide little or no agitation. Chief disadvantage is the fact that more of the active ingredients are lost in the "runoff."

(*c*) Astringent lead arsenate (acid) contains 96 per cent active ingredients. It is the common acid-type lead arsenate with aluminum (alum) added [$Al—NH_4(SO_4)_2 \cdot 12H_2O$]. In Virginia where comparative toxicity tests were made for ten seasons between astringent lead arsenate and standard lead arsenate of the same manufacture, W. S. Hough found that the astringent lead arsenate was usually less toxic to codling moth larvae.

(*d*) Platelet lead arsenate (acid) has gained considerable popularity on the West Coast, especially in the more or less arid regions. The dust particles are flat, irregular, and disklike with a greasy feel.[1] Platelet lead arsenate is not adapted to the rainfall areas in the East.

Basic lead arsenate contains an excess of lead oxide over arsenic oxide (4 to 1). Less water soluble arsenic is formed in this spray and although this results in less foliage injury, some of its insect-killing power is sacrificed. Basic lead arsenate has been widely used on the West Coast for apples, peaches, walnuts, and other fruits, especially in regions of high humidity where the acid lead arsenates may break down and cause burning. It is used in some states east of the Rockies against insects attacking the peach, because its use results in little or no injury to foliage and wood.

The lead arsenate purchased on the market should contain at least 30 per cent arsenic pentoxide. Powdered lead arsenate does not deteriorate with age. It should contain about 20 per cent metallic arsenic equivalent and not over ¾ of 1 per cent of water soluble arsenic (usually about ¼ per cent). The manufacture of lead arsenate is well standardized and there is little danger of getting an inferior product. It can be combined with fungicides such as flotation-type sulfur, lime-sulfur, or bordeaux mixture and with summer oil and nicotine, in making combination sprays.

Arsenate of lead is sold in bags of three, four, and six pounds or in cardboard cartons of one-half or one pound in size. The price may range from 11 to 14 cents per pound in bags, and slightly more for smaller quantities. Before adding to the spray tank, arsenate of lead is placed in a tub or bucket and about one quart of water is added for each pound of arsenate of lead. The two are mixed into a uniform thin paste and poured through the screen into the spray tank. When "safeners" are used, such as zinc sulfate and lime, they are mixed similarly with water and added to the spray tank before the arsenate of lead.

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[1] Information used by special permission from J. A. McClintock and Wayne B. Fisher, authors. Spray chemicals and application equipment. Horticultural Press, La Grange, Ind. 1945.

Calcium arsenate has a relatively high proportion of water soluble arsenic and, therefore, is more likely to cause leaf injury than lead arsenate. It contains 70 per cent active calcium arsenate and 30 per cent inert materials which consist largely of lime. Calcium arsenate has limited use in the orchard because of likelihood of foliage burning and apparently less toxicity to fruit insects than acid lead arsenate. The reason calcium arsenate has been used in orchards is to avoid the lead in lead arsenate, the presence of which may require washing of the fruit before sale. Calcium arsenate is occasionally recommended in the Hudson River Valley of New York for controlling cherry fruit fly when arsenate applications must be made shortly before harvest.

Magnesium arsenate is not safe on fruit tree foliage because shortly after application, the water-soluble arsenic increases several times due to rapid carbonation of the lime.

Zinc arsenate is a relatively new material brought on the market to avoid the lead residue. It is safe on apple foliage, and often used in the Hudson River Valley of New York for control of cherry fruit fly on fruits to be eaten fresh. It is also used in the latter cover sprays for controlling codling moth on apples, but is not quite as effective in control as arsenate of lead. The metallic arsenic equivalent is about 32 per cent. It is not compatible with flotation sulfur and soaps. There is a basic, neutral, and acid form of zinc arsenate. The acid form contains a little over 1.0 per cent water-soluble arsenic, while the basic type has about .5 per cent.[1] Thus, additional zinc sulfate and lime are added as a safener to neutral zinc arsenate. Basic zinc arsenate is used at about the rate of three pounds per 100 gallons of water; it is sold in bags of four-pound size and costs about 15 cents a pound.

The cryolites consist of barium and sodium fluosilicate, and sodium fluoaluminate. These stomach poisons were developed as a means of avoiding lead and arsenic residues on fruits and vegetables. The present governmental tolerance (revised in 1944) for fluorine is .049 grain per pound of fruit.[2] However, it has been recently pointed out that the average person does not obtain sufficient quantities of fluorine on sprayed fruit to be injurious to the body. In fact, it has been demonstrated that a certain amount of fluorine, within definite limits, is essential in teeth preservation.

The cryolites lack adhesiveness and, therefore, a sticker-spreader must be used to maintain effective deposits on fruit and foliage. In the Northwest, the so-called "Dynamite" sticker and spreader is used with cryolite and good control of codling moth has been obtained. However, cryolite has made little headway in eastern orchards because: (1) It has not been as effective as lead arsenate in the second brood sprays against codling moth, and (2) cryolite applied on foliage containing lime residues results in foliage injury. It is usually unsafe to use cryolite on apples within a month after spraying with lime or bordeaux mixture. This may be due to the higher rainfall conditions. With continued good results with DDT on codling moth, there may be little need for cryolites either in the East or West.

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[1] *Ibid.*

[2] This decision was appealed by the Washington State Apple Commission because, "It is the opinion of the apple industry that the evidence in the July-August (1944) government hearings warrants a much more liberal tolerance."

In addition to their use on codling moth, the barium and sodium fluosilicates are used to control flea beetles, strawberry leaf rollers, and insects which cannot be satisfactorily controlled with arsenicals. Trade names include Dutox (barium fluosilicate) and Cryolite (sodium aluminum fluoride). Cryolite sprays contain five pounds of material in 100 gallons of water; dusts are applied at the rate of one part mixed with three to four parts of sulfur, talc, or flour.

Sodium fluoaluminate (trade name Magnetic and Alorco Cryolite) contains not less than 46 per cent fluorine or the equivalent of 85 per cent cryolite plus additional ingredients for improving the physical properties. The particles are very fine and thus mix easily in the spray equipment and settle slowly.

Nicotine bentonite (both a contact insecticide and stomach poison). This is an excellent substitute for lead arsenate, apparently resulting in larger leaves and less likelihood of foliage injury. Its relatively higher cost is the main factor limiting its use. It remains effective as a stomach poison almost as long as it sticks to the leaf and fruit surfaces. Nonalkaline fish oil soap and summer oils are used as sticker-spreaders to prevent spotty coloring of the fruit. Lime or any alkaline material should not touch this spray because the nicotine is quickly freed and the spray made ineffective against insects. No lime should be used on the foliage within two weeks previous to the use of nicotine bentonite in cover sprays.

Commercial nicotine bentonite (trade name Black-Leaf 155) is applied at the rate of one and one-half to three pounds per 100 gallons of water. This spray material not only controls codling moth but is effective against such major insects as apple leafhopper and aphids. Nicotine bentonite can be used either in the latter sprays or throughout the season for controlling all of these insects. The commercial nicotine bentonite is considered better and more economical for the fruit grower than for him to mix the nicotine and bentonite in the orchard. Furthermore, if used in late July or in August, the homemade tank-mix nicotine bentonite sometimes leaves too much visible residue on the fruit and thus detracts from its appearance at harvest time. The bentonite spray is not easily removed by the modern polishing or brushing machines.

Contact insecticides. Contact insecticides not only kill sucking insects but also may be effective against insects having chewing and lapping mouth parts. The main reason for occasionally using these insecticides against chewing insects is to avoid the spray residue problem. Many of the contact insecticides also may be effective against the eggs (known as an ovicide) as well as the larva, pupa, and adult stages of the insect. Common fruit insects against which contact insecticides are effective are codling moth, apple leafhopper, aphid, red mite, flea beetle, currant worm, mealy bug, red bug, and others.

Nicotine sulfate. Nicotine, the alkaloid of tobacco, is the effective killing agent. It is a powerful, quick-acting, very toxic ingredient to most insects. Nicotine can be applied to tender foliage without injury. It is used extensively against aphid, leafhopper, and red bug. Most commercial forms on the market for orchards consist of a concentrated solution containing about 40 per cent nicotine sulfate. Nicotine preparations function best at warm temperatures and where the air is quiet, so that the fumes generated are not immediately blown away. The use of hard water increases the toxic effects of nicotine. Soap acts as a spreader and also may increase toxicity of nicotine.

Nicotine is used either as a dust or a spray. When used as a spray, the 40 per cent solution is added directly to the spray tank. When used as a dust, it is mixed with a suitable carrier, as hydrated lime. About 2 per cent nicotine dusts are commonly used and must be kept in tight containers to preserve the killing power. Nicotine sprays in general have the disadvantage of being relatively expensive. They also may cause severe nauseation if breathed excessively while applying.

Although it is not entirely necessary for the nicotine spray to hit the insect, the fumes must reach it to be lethal. If nicotine sulfate is used alone in a spray tank, it is easily volatilized, particularly during hot weather. For this reason, other materials, such as oils, are usually added to delay the rate of volatilization. If summer oil is mixed with the nicotine, the spray also acts as an ovicide.

Nicotine and summer oil. Commercial ready-mixed nicotine and summer oil combinations are available on the market. The use of bentonite in this combination is not necessary. As a stomach poison, the combination of nicotine (40 per cent) and summer oil may not persist as long as the nicotine-bentonite products. The nicotine-oil product is primarily a contact insecticide and gives effective control of leafhoppers, aphids, and codling moth larvae, adults and eggs. This product is applied at the rate of three quarts in 100 gallons of water. Where a stomach poison is necessary, it can be mixed with one and one-half pounds of Black-Leaf 155 or three pounds of lead arsenate.

Fixed nicotine compounds. The insecticidal properties of nicotine are better retained by impregnating the nicotine sulfate or "free nicotine" in bentonite clay. This compound acts primarily as a stomach poison but is of minor importance as a contact insecticide. It has been described previously under stomach poisons. Fixed nicotine is sold under the trade name of Black-Leaf 155 and can be used in combination with summer oil to kill eggs of the codling moth.

DDT. This is a synthetic organic compound developed by Zeidler in Germany in 1874. It was first tested by Paul Müller as an insecticide in Switzerland in 1939. Insecticide patents were taken out in England in 1940 and in the United States in 1943. The generic name of the compound is dichlorodiphenyltrichloroethane from which the name, DDT, is derived.

Experimental work with DDT has indicated that it is superior to lead arsenate in control of codling moth. It is highly effective against the grape berry moth, Japanese beetle, rose chafer, and leafhoppers. It has failed to control plum curculio, European red mite, Pacific mite, and wooly aphis. In fact, the latter three insects have shown marked increases under some conditions where DDT was used in the spray program because this insecticide kills their important parasites and preditors. DDT is lethal to pollinators such as honeybees but fortunately, this fact is not particularly alarming to either beekeepers or orchardists as long as DDT is not used while the trees are in bloom or in the petal-fall spray, but is limited to the cover sprays in accordance with present practices.

The toxic properties of DDT to human beings has not been fully determined, although preliminary experiments with rabbits have shown that DDT may accumulate in the fat tissues. A tentative tolerance of DDT residue on apples and pears amounting to seven parts per million or .049 grain of DDT per pound of fruit has been suggested by the Food and Drug Administration. Investigators in the U. S. Public Health Service have stated that, "Although DDT is deadly to many insects, it is not harmful to man if properly applied. DDT is definitely less toxic than Paris green and sodium fluoride—long in use as common insecticides. But as with any insecticide, there are certain precautions which must be taken to avoid any possible harmful effects."

The amount of DDT being used in codling moth sprays is three-quarters to one pound of actual DDT in powder formulation per 100 gallons of spray (if a 50 per cent DDT wettable powder is used, the amount for 100 gallons is about one and one-half to two pounds). In Virginia, Hough states that DDT is apparently safe on apple trees when used with any of the following spray ingredients: wettable sulfur, flotation sulfur, lime, zinc sulfate plus lime, bordeaux mixture, or lead arsenate. DDT can be used with lime-sulfur and summer oils, but its toxicity to codling moth is apparently reduced. The use of commercial DN-111 at the rate of one-quarter-pound, or Genicide one pound per 100 gallons, in one or two sprays after the last cover spray, reduced the European red mite and apple mite considerably. Inasmuch as DDT tends to lose its strength with time on apple trees, it is necessary to apply from five to six applications during the growing season.

As experimental data accumulate, it is increasingly clear that DDT will likely replace lead arsenate in cover sprays for codling moth control. It would be well for the grower to keep in close touch with the recommendations of his local experiment station.

Oils and dinitros. Oil sprays have the ability to spread and permeate each crack and crevice; they possess considerable insecticidal qualities, but are of no value as a fungicide. They are effective against scales and eggs of the European red mite and aphids. Oils are pleasant to use and do not corrode metal parts, but they do cause rubber parts other than synthetic rubber to deteriorate. Oils may be divided conveniently into dormant and summer spray oils.

Dormant spray oils. There are several oils for dormant use which are suited to particular needs of the grower. They may be classified as follows:

1. Dinitro with petroleum oil
2. Petroleum oil:
    - (*a*) Concentrated or mayonnaise-type emulsions
    - (*b*) Miscible oil
    - (*c*) Emulsible oil
    - (*d*) Tank-mix oil

Dinitro with petroleum oil. The so-called dinitro compounds are added to petroleum oils to make them more effective against the eggs of the aphids and other pests during the dormant season. Although the dinitro compounds have been sold in solution with the oil, the present marketing procedure is to offer the dinitro preparations separately in powder form so that they can be added to any oil spray in any desired amount, or used in water alone as an ovicide against aphid eggs. This is an advantage because the powder can be varied in the spray according to the insect problem at hand. It is important that the directions on the package be followed, inasmuch as different manufacturers use different amounts of the active ingredient in their dinitro products.

A water suspension of sodium dinitro-ortho-cresylate, commercially known as Elgetol or Krenite, is also available on the market either to be used alone against aphids, or, with oils to control other pests as well. These preparations should not be allowed to dry, since the dry ingredient burns when exposed to open flame. The manufacturer's recommendations should be followed.

Dinitro with oil is especially recommended where rosy apple aphis or the black cherry aphis is a definite problem. Spray must be applied when the trees are completely dormant, and spraymen should be protected from the drift.

Petroleum oils. These oils are popular in dormant spraying because of their (1) low cost, (2) general agreeableness to use, (3) noncorrosive action on spray machinery, and (4) efficiency in orchard clean-up. Petroleum oils now sold usually have similar types of base oil but contain different emulsifying agents. All should be equally effective if used at the proper recommended strengths. The spray rig should provide vigorous agitation to insure uniform distribution of oil in the tank.

(*a*) Concentrated or mayonnaise-type emulsions contain from 65 to 85 per cent oil. They are commercially prepared or they can be made at home.

In order to compensate for their lower oil content, a heavier dosage of these oils is required as compared with miscible or emulsible oils described below. With the pump running, the emulsion is added to a small quantity of water already in the tank and it mixes easily. Excessive heat may cause the emulsion to break. Therefore, they should be stored at moderately cool temperatures of 40° to 50° F. Their chief advantages are (1) low cost, and (2) ease of mixing. The commercially prepared oil emulsions are more convenient and usually safer, especially for the smaller fruit grower.

(*b*) Miscible oils contain from 93 to 99 per cent oil and are manufactured from such oil stocks as red engine oils or the paraffin oils. The emulsifying agent is already dissolved in the oil and, therefore, the mixture is added to the spray tank and emulsified easily with agitation, forming a very stable emulsion. The oil droplets are small and give a very uniform deposit on the dormant trees, although the deposit is usually not as heavy as that obtained with other types of oils. Miscible oils which do not contain an "antifreeze" agent (such as diethylene glycol) will break on dilution in water after being exposed to a temperature several degrees below freezing.

(*c*) Emulsible oils contain 95 to 98 per cent oil and a dissolved emulsifier. However, in the tank they require good agitation to emulsify them. For a given concentration, they generally deposit more oil on sprayed surfaces than do the miscible type oils, which is desirable. Emulsible oils now available will withstand freezing. They are sometimes called "quick break" oils because the oil droplets break away from the water as soon as the mixture is applied to the tree.

(*d*) Tank-mix oils are emulsified in the spray tank by the addition of an emulsifier. They can often be prepared at a saving in cost as compared with proprietary oils. Tank-mix oils are usually of the lubricating- or transformer-type and have the following specifications:

Viscosity—from 75 to 150 sec. at 100° F. (Saybolt)
A.S.T.M. distillation—less than 10 per cent off at 560° F.
A.P.I. gravity—minimum 21.5
Unsulphonatable residue (A.S.T.M., D-483-40)—Minimum 6.5

Motor oil or crank case drainings are unsuitable for spray purposes because they may contain impurities toxic to the foliage.

The two tank-mix formulas listed below are more widely used than others.

Formula 1. Lubricating oil—three gallons
Copper sulfate (fine crystals)—one-half pound
(this is the emulsifier)
Hydrated lime—three-quarters-pound
Water to mix—100 gallons

These quantities are doubled, tripled, or quadrupled if 100, 200, or 300 gallons are desired. This mixture will give a 3 per cent oil spray. For a 4 per cent spray, use four gallons of oil to each 100 gallons of spray.

In preparing the tank-mix oil, place enough water in the tank to reach the agitator shaft. Start the pump, place the copper sulfate on the screen, and wash it into the tank. Next, sift in the lime and add the oil. Continue pumping until all the oil is emulsified, and no free oil shows on the surface. The tank is then filled with water and without shutting off the engine, the rig should be taken to the orchard for spraying.

Formula 2. Lubricating oil—three gallons
Calcium caseinate—six ounces (the emulsifier)
Or, Goulac—six ounces
Or, Blood Albumin emulsifier—eight ounces
Water to make—100 gallons

This formula is prepared in the same order as Formula 1. Sift the calcium, caseinate, or goulac, or blood albumin into the small amount of water that is being pumped, then add the oil and continue pumping until the emulsification is complete. Fill the tank with water and spray immediately.

Either of the above formulas may be combined with bordeaux mixture as an early spring dormant spray for the control of peach leaf curl, in addition to controlling scale or red mite.

A word of caution should be made in connection with the use of petroleum oil sprays. Bear in mind that: (1) Some concentrated oil sprays will not freeze, and that others will. Know the type of oil you are using and protect it from cold or excessive heat. (2) Do not spray with oils if temperatures are below 40° F., or if low temperatures are forecast for the next 24 hours. Oil injury to the trees may result. (3) Do not spray with free oil floating on top of the spray solution in the tank. (4) Dormant oils are most effective against insects during the late dormant period and when the buds are showing green tips. Spraying with oils should stop when the green leaf tips are as long as mouse ears. (5) In the extreme northern part of the United States where the temperatures may drop quickly below freezing in the fall of the year, dormant oils may cause injury if applied a short time previous to such a drop in temperature. In the latitude of northern Virginia and southward, fall applications of dormant oil have been as safe as spring applications.

Summer spray oils. Only the *highly refined petroleum oils* should be used in summer spraying. This is to protect the tender foliage and fruits against any toxic impurities present in unrefined oils. Summer oils may fall into any one of the four groups given above under dormant oils. Specifications for summer oils, however, are much more exacting, and it is suggested that they fall within the following limits.

Viscosity from 65 to 90 sec. at 100° F. (Saybolt)
A.P.I. gravity—27-35

Unsulphonatable residue (A.S.T.M., D-483-40)
—minimum 90 per cent
Distillation range:
  10 per cent point—not less than 560° F.
  90 per cent point—not over 760° F.
  50 per cent distilled—when temperature reaches 636° F.

The summer oils are used in combination with nicotine as described previously against codling moth and also with lead arsenate. They increase the effectiveness of nicotine sprays against aphids, leafhoppers, and other sucking insects.

MATERIALS FOR DISEASE CONTROL

Chemicals which control fungus diseases by their chemical action are known as *fungicides.* Sulfur and copper continue to be the best and most active ingredients for fungicides. Hydrated lime is commonly added to neutralize any caustic action that might accompany the use of copper or sulfur. The fungicides primarily prevent germination of the spores and the establishment of the fungus upon the host, although some of the more caustic fungicides such as liquid-lime sulfur may "burn out" the fungus after it is established.

Sulfur fungicides. Sulfur fungicides can be placed in two groups: Group 1—sulfur combined to form sulphides with calcium, sodium or potassium; and Group 2—sulfur uncombined as in the wettable or elemental sulfurs. A chemical reaction takes place in Group 1, in which complex sulphides are formed which are known to be very caustic and with high fungicidal value; they are very unstable when exposed to air. They form elemental sulfurs after being sprayed upon the tree, which insure their lasting effectiveness as a spray. Generally speaking, they are apt to cause injury to most types of foliage and should not be employed in spray schedules to be used on the tender foliage of peach, plum, and sweet cherry. Examples of Group 1 sulfurs are liquid-lime sulfur and dry-lime sulfur.

In the uncombined sulfurs of Group 2, a mechanical mixture is prepared in the factory in which the sulfur remains insoluble. When placed in the spray tank, it remains in suspension and does not go into solution. Although this type of sulfur is less effective as a fungicide, it causes practically no injury to the foliage of fruit trees except when used under conditions of extremely high temperatures, i.e., 90° to 95° F. shade temperature. Group 2 sulfurs are widely used today and are known as the elemental or wettable sulfurs.

Liquid-lime sulfur (Group 1) was formerly used for dormant spraying, but it has been largely replaced by the dormant oils because lime-sulfur has the disadvantages of (1) high cost of spray, (2) failure to control red mite, and (3) irritation to the eyes and exposed parts of the body. It is no longer

TABLE 22

AMOUNTS OF LIQUID-LIME-SULFUR FOR DORMANT SPRAYING ON PEACHES, AND PREBLOSSOM SPRAYING ON APPLES AT DIFFERENT BAUMÉ READINGS

HYDROMETER READING	AMOUNTS PER 100 GALLONS OF SPRAY				
	Peach-Dormant Spray		*Apple*		
	Scale Present	*No Scale*	*Delayed Dormant* 2-100	*Prepink and Pink* 1½-100	*Postbloom* 1-100
Degrees Baumé	Gal.	Gal.	Qt.	Qt.	Qt.
33	12½	6¼	8	6	4
32	13½	6¾	8⅔	6½	4⅓
31	14½	7¼	9⅓	7	4⅔
30	15½	7¾	10	7½	5
29	16¾	8¼	10⅔	8	5⅓
28	17¾	8¾	11⅓	8½	5⅔
27	18¾	9¼	12	9	6
26	19¾	10	12⅔	9½	6⅓
25	20¾	10½	13⅓	10	6⅔

recommended as a dormant spray except for peach leaf curl for which it is superior. If scale insects are not a problem on peaches, the liquid-lime sulfur can be cut to half strength or six and one-quarter gallons of liquid-lime sulfur per 100 gallons for leaf curl.

Until about 1935, liquid-lime sulfur was the standard spray material for scab on apples. In recent years, however, due to frequent foliage burning and fruit russeting and to reduction in photosynthetic capacity of the leaves, liquid-lime sulfur sprays have been largely replaced by the less caustic sulfurs. Lime-sulfur combined with lead arsenate seems to increase foliage injury, and for this reason, the flotation-type sulfur has largely replaced liquid-lime sulfur in sprays after blossom drop. Liquid-lime sulfur in weak dilutions is still being recommended, however, in prebloom stages, and at other times when apple scab has become well established due to weather conditions favorable to scab development.

If liquid-lime sulfur is held over winter, it should be sealed to exclude air and stored where it will not freeze. The freezing point of concentrated liquid lime-sulfur is below the freezing point of water. If the material has been frozen, it should be tested with a Baumé hydrometer[1] before it is used the following spring. As shown in Table 22, if the Baumé reading is low (25°), more concentrated liquid-lime sulfur is used per 100 gallons of spray than if the reading is high (33°).

Practically all commercial brands of concentrated liquid-lime sulfur are of equal value, provided the Baumé reading is between 32° to 33° F. Lime-sulfur is the most important member of the sulfide group. The sulfur is largely in the form of pentasulfides (a maximum combination of sulfur with lime), in which form it is the most effective as a fungicide.

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[1] Obtainable from chemical laboratory equipment companies at a nominal cost.

Years ago, many growers manufactured liquid-lime sulfur solutions at home because of a saving in cost. In recent years, however, due to large scale production, the cost per gallon has been lower and most growers purchase their required needs in 50-gallon drums. Detailed information on home-manufacture of liquid-lime sulfur, if desired, is given by Ballou.

Dry-lime sulfur (Group 1) contains the same ingredients as liquid-lime sulfur except that a stabilizer has been added which makes its manufacture possible. The advantage of dry-lime sulfur over liquid-lime sulfur concentrate is the greater convenience in handling, shipping, and storing. Dry-lime sulfur is safer than liquid-lime sulfur on foliage and equally effective as a fungicide if the amount used contains the equivalent polysulphide content. Therefore, although the cost is slightly greater, it is preferred for summer spraying on apples. About four pounds of dry-lime sulfur is equivalent in calcium polysulphide content to one gallon of liquid-lime sulfur concentrate.

Wettable sulfur sprays (Group 2) or the noncombined sulfur sprays are noncaustic and rarely cause injury to foliage. Good finish of the fruit is associated with their use. However, many wettable sulfurs lack efficiency in control, especially on such apple diseases as Brooks spot, bitter rot, and blotch. If these diseases are not a problem, a flotation-type of sulfur is usually recommended to prevent scab infection after the prepink stage of apples.

A small amount of lime (two or three pounds per 100 gallons) is preferred with wettable sulfurs because of its flocculating value and to reduce the hazard of sulfur sun-scald. The manufacturers' directions should be followed. A description of some of the better known wettable sulfurs is given below.

(*a*) Flotation type sulfur. This is one of the most effective wettable sulfur sprays for controlling apple scab. It is made from a by-product in the manufacture of artificial gas. Flotation sulfur is colloidal in nature, considerably smaller in particle size than flowers of sulfur, suspends well in water, contains a trace of insoluble material, and is sold on the market in either paste or powder form. The paste form sold in 50-gallon barrels is the most popular among fruit growers. Flotation sulfur has been found to be effective in many eastern states in controlling scab, especially during the post-bloom period. Several flotation sulfurs are offered on the market. They contain about 40 to 50 per cent sulfur and are used at a greater concentration before bloom (12 pounds to 16 pounds in 100 gallons of water), than after bloom (six to ten pounds in 100 gallons). In addition to the common flotation sulfurs, there are some prepared forms of sulfur pastes that physically resemble the flotation form.

(*b*) Other wettable sulfur sprays. Among the commercially prepared wettable sulfur compounds are the following: Dritomic, Kolofog, Magnetic, Micronized, Mike, Mist Brand, Mulsoid, and Sulforon. In many of these sulfurs, the object is to obtain as small a particle size as possible. Most wettable sulfurs are below ten microns in particle size (a micron is 1/25000 of an inch). Sulfur particles larger than 27 microns do not adhere to the foliage sufficiently well to be of fungicidal value. The smaller the particle size, within limits, the more effective the fungicidal control and the better the sulfur adheres to the leaf or fruit surface. However, sulfur particles smaller than one-half of one micron are of little fungicidal value because there is little tendency for the particles to settle out of the spray droplet.

Most of the above wettable sulfurs were developed primarily for peach spraying, but they have been found to be quite satisfactory for apple scab control after the bloom period. The manufacturer's directions should be followed as to strength, whether the wettable sulfur is used alone or to supplement weak liquid-lime sulfur.

Wettable sulfur can be made at home with a saving in cost. The dusting sulfur must be mixed with a wetting agent in order for it to be wetted by water. The following ingredients are mixed dry: ten pounds of a fine grade of dusting sulfur, eight ounces of dried skim milk, and one ounce of a wetting agent. Several suitable wetting compounds can be obtained on the market, among which are Aresklene, Santomerse, Tergitol, Grasselli Spreader and Sticker, and Orthex. Homemade wettable sulfur can be used in the same way and in the same amounts as any of the commercial wettable sulfurs.

The copper sprays. The coppers are usually employed during the warm summer weather when there is less likelihood of injury. Copper sprays, and especially Bordeaux mixture, are more likely to cause foliage burning and fruit russeting during the cool moist spring months. Bordeaux also seems to aggravate leaf drop on apple trees during hot dry periods under conditions such as found in southern Ohio. Coppers are specific and effective against certain diseases which sulfur will not adequately control. However, Fermate, a sulfur derivative, is showing promise against blotch and certain other apple diseases commonly controlled by Bordeaux. Also, Fermate is showing less foliage injury.

The following fruit diseases are commonly controlled by copper sprays: cherry leaf spot, apple and pear scab (with reservations), peach leaf curl, black rot of grape, fire blight, brown rot of cherries and plums, leaf spot of plums, black knot of plum, black spot of quince, anthracnose, powdery mildew, leaf spot of gooseberries and currants, and anthracnose of raspberries.

Bordeaux mixture. Bordeaux mixture is the combination of copper sulfate (known also as blue vitriol), hydrated lime, and water. A commonly used Bordeaux formula is 6-8-100, meaning six pounds of copper sulfate, and eight pounds of hydrated lime in 100 gallons of water. There has been a tendency in recent years to decrease the amount of copper and increase the amount of lime in Bordeaux mixtures used on fruit trees. Such a mixture is safer on the foliage and appears to have equally satisfactory fungicidal value.

Although a prepared Bordeaux mixture is available on the market, it is relatively expensive for use in commercial orchards. Proprietary Bordeaux is used mostly on a small scale in home fruit orchards. Commercial fruit growers usually prepare Bordeaux mixture while filling the spray tank with water. Two general methods are in use. The standard method is No. 1 below.

Method 1. Copper sulfate can be purchased in large crystals or in powdered form. If crystaline copper sulfate is used, a stock solution should be prepared by mixing one pound of the crystals with each one gallon of water. The necessary amount of crystals can be placed in a cloth sack and suspended in the proportionate water until they dissolve. They dissolve more quickly in warm water, but will dissolve overnight in cold water. The stock hydrated lime is prepared in a tub or bucket by mixing the required amount of lime with sufficient water to form a thin paste. The paste is washed through the screen at the top of the spray tank by using the spray gun under pressure.

For example, to prepare a 500-gallon tank of a 4-8-100 Bordeaux mixture, fill the tank two-thirds full of water and start the engine to keep the agitator running. Mix the 40 pounds of hydrated lime into a cream paste in a large bucket or small tub, and wash it through the strainer into the tank; when the lime is thoroughly mixed, add 20 gallons of copper sulfate stock solution. Fill the tank to 500 gallons. If lead arsenate is used, it should be added last.

Method 2. The instant or powdered copper sulfate is used in this preparation, and, therefore, it is not necessary to prepare a stock solution of copper sulfate. The procedure is as follows: Fill the tank half full of water and with the agitator running, wash the hydrated-lime paste through the screen. Fill the tank to two-thirds to three-fourths of capacity, place the powdered copper sulfate on the screen and wash it through with the spray hose. Completely fill the tank with water.

Fixed copper compounds. Due to occasional foliage and fruit injury with Bordeaux mixture, manufacturers have developed the so-called insoluble copper compounds, or the colloidal copper compounds. In general, they are not as effective in disease control as Bordeaux, but are less injurious to the fruit and foliage.

There are two general types of fixed coppers recommended for tree fruits: (1) the basic copper sulfate group of which the tri-basic forms are generally used, including such brand names as Basi-Cop, Spray-Cop, and Tri-Basic; (2) the second group includes the basic copper chlorides, namely, copper oxychloride, oxychloride sulfate, and Copper Compound A. The chemistry of these compounds is extremely complex and hundreds of the chlorides and sulfates of copper can be made. The concentration of copper in each of these varies considerably, ranging from 12 to 56 per cent metallic copper. Although there is a definite variation in their effectiveness and safety per unit of metallic copper, it is recommended that all spray formulas be calculated on a uniform copper basis. For example, relatively less of the compound by weight would be needed if the metallic copper content were 50 per cent as compared with 25 per cent.

Fixed coppers are primarily used to control cherry leaf spot and have given good control under eastern conditions. Lime must be added according to the local recommended schedule. Fixed coppers may cause foliage and fruit injury on apples if applied before midsummer.

NEW SPRAY CHEMICALS

Fermate. Chemically, fermate is ferric-dimethyl-dithio-carbamate. It was developed during World War II, and is showing considerable promise in the control of peach diseases, cedar rust, leaf spot of sweet and sour cherries and pear scab. It is reported to be a repellent for the Japanese beetle. Fermate is safer on more types of foliage than either copper or sulfur because it is less affected by climatic changes in the northern climates, such as found in Ohio. It has proven effective against bitter rot and cedar rust in regions where Bordeaux mixture has caused serious injury. Fermate is compatible with all types of wettable sulfurs, arsenate of lead, calcium arsenate, nicotine, DDT, oils and to a limited extent with hydrated lime.

Methasan and Zerlate. Methasan and Zerlate are the zinc salt of an organic sulfur, whereas Fermate is the iron salt of the same chemical. Preliminary trials indicate that this fungicide is less effective than Fermate. It is used in the control of cherry leaf spot and apple scab.

Puratized. Puratized is an organic mercury fungicide containing no sulfur. It is used in the extreme dilutions of one part to 8000 to 10,000 parts of water, and in a number of trials on Grimes Golden has shown excellent control of bitter rot and apple scab. It does not stunt the fruit as compared with bordeaux mixture. Puratized is compatible with lead arsenate, hydrated lime, nicotine, and DDT. It has a lasting effectiveness as a fungicide, probably due to the fact that it carries a positive electric charge, whereas the leaf carries a negative charge, or it is absorbed into the epidermis of the leaf and remains there, acting as a preventative and curative fungicide.

However, the question of mercury residues will likely arise if this material is used to any extent on fruit trees. Not even a trace of mercury is tolerated by the U. S. Government on food products.

Dow DN-111. Chemically, this insecticide is di-nitro-o-cyclohexylphenol. It is used in summer spraying at the rate of one and one-fourth pounds in 100 gallons against the red mite for which it shows excellent control. It is compatible with lead arsenate and in cool weather with wettable sulfur (it is not safe when the temperature is 80° F. or likely to rise to 80° within a week after spraying) but *not* with summer oil, liquid-lime sulfur, bordeaux mixture, or zinc sulfate and lime. It should not be applied on sulfur residue when the temperature exceeds 80° F. There is a dust form available known as DN-dust-"D4." It is often applied with DDT for summer sprays on apples to control red mite.

Xanthone. This organic chemical has shown promising results in California for late brood codling moth, leafhoppers, and spider mites. It results in better foliage and fruit than lead arsenate. There is no spray residue problem. It should not be used with oil.

Phenothiazine. This material is not new, but a recent micronized form has shown promise in California in control of codling moth with little or no injury to the foliage. In the Pacific Northwest, phenothiazine has been reported to decrease red color and size of apples. It leaves a grey residue removable by standard washing procedure; however, there is no government tolerance on this chemical.

In the Shenandoah-Cumberland fruit area of Pennsylvania, Maryland, and the Virginias, a combination of two pounds of phenothiazine and three pounds of lead arsenate per 100 gallons has been used extensively with excellent results against codling moth.

Others. Hexaethyl tetraphosphate, a 50 per cent solvent mixable with water, is very toxic to red mite and aphid as a contact spray. It decomposes rapidly in the presence of water. Benzene hexachloride (Hexachlorocyclohexane) chlordane, Rhothane (DDD), thiophos 3422 (Parathion), and others have shown promise, but more experience is needed with them for a full evaluation. Thiophos 3422, manufactured by the American Cyanamid Company, in early trials was effective against all apple insects encountered at 75 experiment stations and apparently was nontoxic to humans as well as the tree foliage. More new spray chemicals were developed during and after World War II than in any time in history, and some of them have made a great difference in profits in fruit growing.

HCCH. This symbol refers to hexachlorocyclohexane, benzene hexachloride, gammixane, or 666. These names and several trade names refer to a mixture of closely related chemical substances. As now sold HCCH has a persistent odor. It is strikingly effective against some insects. The residual effect is too short to displace DDT against insects killed by DDT. HCCH is partly effective against mites, and is being used to some extent on peaches against curculio, and against grasshoppers in nonbearing orchards.

HETP. Hexaethyl tetraphosphate, sometimes referred to as "Bladen," is ordinarily sold as a 50 per cent solution miscible with water. No damage on tree foliage has been recorded. It mixes with oil and wettable sulfurs and is a contact spray without marked residual effect or residue. HETP breaks down in water and thus should be applied soon after mixture. HETP, in early studies, appeared to be an excellent material for control of mites, aphis, and pear psylla. One pint of the 50 per cent material per 100 gallons of spray seems to be an effective concentration. HETP is a poison; the concentrate should not contact the skin, even as a dilute spray. Avoid breathing the mist for prolonged periods while spraying.

Dithane disodium ethylene bisdithiocarbamate. This material has been sold as powder and liquid. It has given commercial control of leaf spot on sour cherry and scab on apples in experimental plots in Michigan. Dithane is compatible with oil, wettable sulfur, lead arsenate, nicotine sulfate, and fixed nicotines.

ORDERING SPRAY MATERIALS

Spray materials should be ordered several months in advance of the spray season. The first consideration in ordering is to determine as nearly as possible the spray schedule to be followed, especially during the early part of the season. This schedule can be obtained from the local agricultural extension service. It will suggest the number of sprays to be applied, the materials to be used, and the dilutions. Every grower should request that his name be placed on the regular mailing list for spray schedules and other spray information from the local county agricultural agent.

Considerably more spray material will be required for the afterbloom than for the prebloom applications. Table 23 gives the average gallons of spray solution required for the season for different fruit trees of different ages. From this information, the amount of spray materials needed can be estimated.

TABLE 23

Approximate Gallons of Spray Solution Required for Fruit Trees by Age
(Adapted from Ohio Agr. Exp. Sta. Bull. 655, 1947)

Age of Trees	Average Amount per Application for Season in Gallons			
	Apples	*Peaches*	*Sour Cherries*	*Sweet Cherries*
2 to 3 years	.5	.7	.5	.5
5 years	1.5	3.0	2.5	1.5
10 years	6.0	5.5	6.0	6.0
12 years	8.0	6.0	8.0	8.0
15 to 20 years	12 to 20	6.0	10.0	10.0
21 to 25 years	20 to 35		12.0	15 to 18

TIME AND AMOUNTS OF SPRAY APPLICATIONS

Most insects and diseases tend to build up as the growing season advances. It is, therefore, particularly important that the correct materials be thoroughly applied at the proper time early in the season in order to reduce as much as possible the early generations of insects and diseases. Burkholder and Lehker state that the progenies of a single overwintering codling moth, if uncontrolled, can destroy about 145 bushels of apples in one season. To effectively control codling moth, it is often good judgment early in the season to apply "top-off" sprays between the regular cover sprays[1] in order to adequately cover the treetops and to keep the rapidly expanding surface of the young apples covered with spray materials. As shown in Figure 203, the surface area of young apples may double every seven days early in the season.

Most fungus diseases thrive best in the presence of moisture from con-

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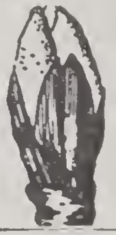
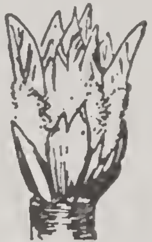
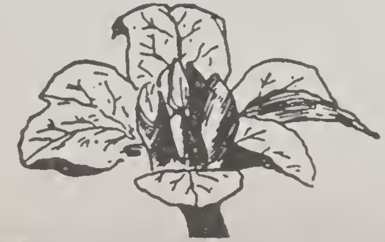
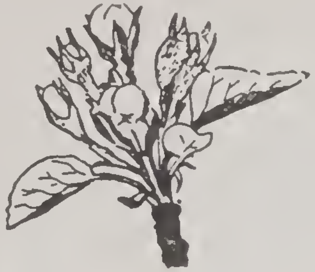
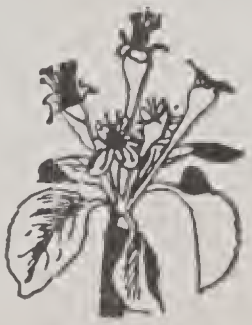
[1] A cover spray is one applied after the blossom petals fall, the chief purpose of which is to keep the fruit surfaces covered with a protective layer of spray.

TABLE 24[1]: Apply Spray Schedule from Michigan State College, 1946 (Michigan Agricultural Extension Bulletin 154)

Application	Materials		To Control	Explanations
1. DORMANT. Complete before green tips appear. 	Lime-sulfur 12 gal.; or dormant oil, 3% actual oil; or DN.		Scale insects, mites and leaf rollers. Lime-sulfur will control scale. Oils will control scales, mites, and leaf rollers. Tar sprays and DN sprays will control aphids. Tar and oil, and DN and oil will control aphids, mites and scales.	The dormant application of oil is necessary for the control of mites and leaf-rollers and will also control scale. Lime-sulfur may be used if scale only is to be controlled.
2. DELAYED DORMANT. Apply in a well developed green-tip stage, when leaf tips are ¼ to ½ inch in length. 	Lime-sulfur 2 gal.; or wettable sulfur 5 to 8 lb. Nicotine sulfate 1 pt.	These applications are the most important for scab control.	Scab, aphid, and bud moth. Omit the nicotine sulfate if a dormant application of DN or tar, tar and oil has been made.	This is the best period for the control of aphis, if this has not been affected by dormant applications, and the lime-sulfur that is necessary with the nicotine will prevent early infection of apple scab. Lead arsenate is partially effective against bud moth.
2a. PREPINK. Begin soon after the delayed dormant condition and complete as soon as possible. 	Lime-sulfur 2 gal.; or wettable sulfur 5 to 8 lb. Lead arsenate 3 lb.		Scab, curculio, and bud moth. If aphids have not been controlled by this time nicotine should be added as satisfactory aphid control cannot be expected later than the prepink application.	Apply the prepink on the more susceptible varieties and on all varieties when conditions seem very favorable for scab development, or in seasons when bud development is spread over a long period. Still another application for scab control between the prepink and pink applications may be desirable under extreme conditions.
2b. EARLY PINK. When the	Wettable sulfur 5 to 8 lb.		Scab.	

3. PINK. Begin to apply as soon as most of the buds have separated in the clusters and complete before the blossoms open. 	Lime-sulfur 2 gal.; or wettable sulfur 5 to 8 lb.	These applications are the most important for scab control.	Apple scab, curculio and other chewing insects.	This application is important for scab control. The lead arsenate is of value for the control of chewing insects, as well as increasing the fungicidal value of the lime-sulfur. Do not use lead arsenate after the blossoms begin to open. Bees may be poisoned and pollination of early bloom reduced.
3a. IN BLOOM. When trees are in full bloom.	Wettable sulfur 5 to 8 lb.		Scab.	

This Schedule Will Make Residue Removal Necessary.

4. PETAL FALL (CALYX). Should be made when most of the petals have dropped and after bees have quit working in the bloom. 	Lime-sulfur 1¼ gal.; or wettable sulfur 5 to 8 lb. Lead arsenate 2 lb.	These are the important applications for codling moth control.	Scab, codling moth, curculio, other chewing insects, and red bug. Wettable sulfur may be substituted at this time.	Spraying should not begin until most of the petals are off and there are no bees working in the trees, but should be completed as soon as possible.

(Continued on following Page)

This Schedule Will Make Residue Removal Necessary.

5. FIRST COVER. Seven to ten days after petal fall.	Wettable sulfur 4 to 6 lb. Lead arsenate 3 lb.	These are the important applications for codling moth control	Codling moth, curculio, lesser apple worm, and scab.	WARNING. IMPORTANT. Govern use of lead arsenate during the summer by the prevalence of codling moth.
5a. SECOND COVER.[2] Seven to ten days after Application 5.	Zinc sulfate 1 lb. Lime 4 lb. Lead arsenate 4 lb. Wettable sulfur 4 to 6 lb. *or* Wettable sulfur 4 to 6 lb., DDT ¾ lb.		Codling moth, curculio, lesser apple worm, and scab. If apple scab is prevalent, the use of wettable sulfur may be advisable at this time.	
5b. THIRD COVER.[2] Ten to fourteen days after 5a.	Zinc sulfate 1 lb. Lime 4 lb. Lead arsenate 3 lb., DDT ½ lb. *or* DDT ¾ lb.		Codling moth, lesser apple worm, and curculio.	
5c. FOURTH COVER.[2] Two weeks after 5b.	Zinc sulfate 1 lb. Lime 4 lb. Lead arsenate 3 lb., DDT ½ lb. *or* DDT ¾ lb.		Codling moth, lesser apple worm, and curculio.	
6. SUMMER GENERATION.[2] Exact time to be determined each year, usually about Aug. 1.	Zinc sulfate 1 lb. Lime 4 lb. Lead arsenate 3 lb. Wettable sulfur 4 to 6 lb. *or* DDT ¾ lb.		Codling moth, curculio and scab.	The exact time of this application is determined by the Entomology Department and announcement is made through county agents.
7. Two weeks after Application 6 and if necessary make one or two more applications at 2 week intervals.	Zinc sulfate 1 lb. Lime 4 lb. Lead arsenate 3 lb. *or* Fixed nicotine. Manufacturers' recommendations.		Codling moth and curculio.	

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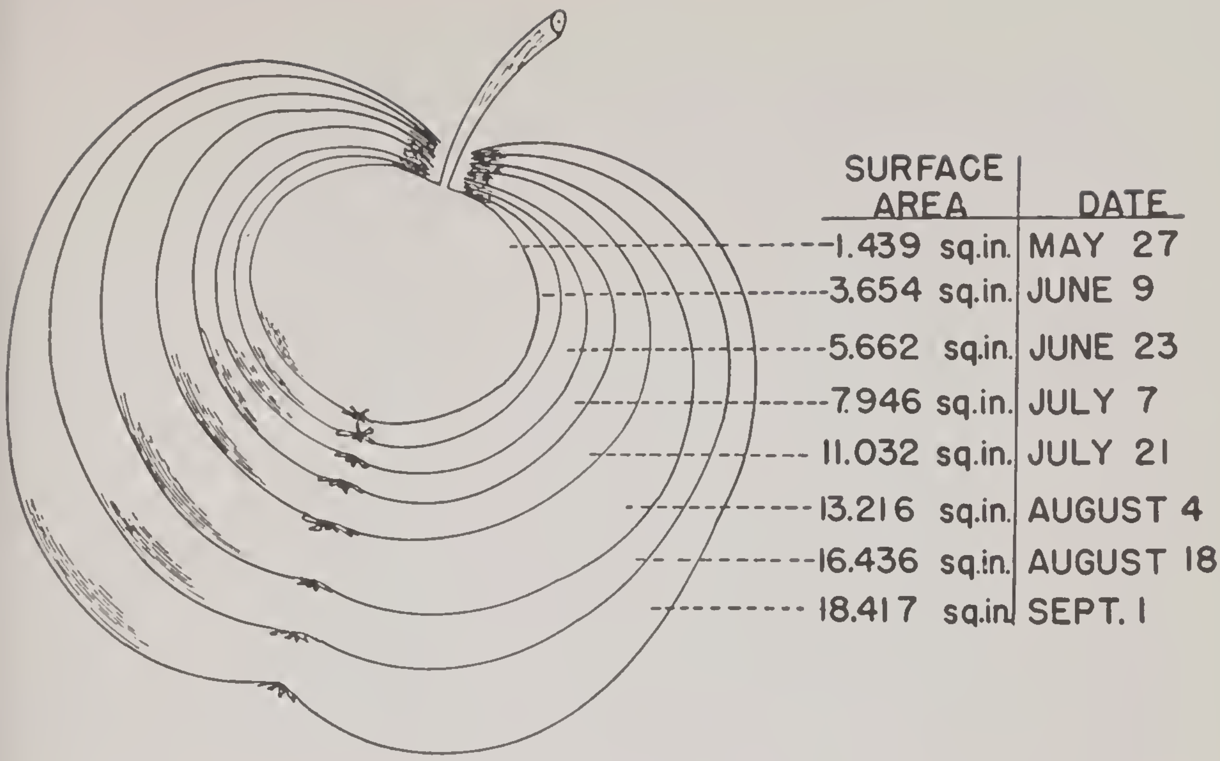
[1] The addition of one pound of lime in 100 gallons of spray containing wettable sulfur helps to "stick" the sulfur.

[2] If conditions have been especially favorable for development of apple scab and it has not been controlled, a fungicide may be applied in any of the cover sprays.



JONATHAN

New Mexico Agr. Exp. Sta.

Figure 203. It is shown here that Jonathan apples about double their surface area every two weeks to a month during early development. Thus, there is a great need for frequent sprays to keep the fruit surface covered.

tinued rains. During such periods, the spores readily germinate and the organism becomes established on the host, provided temperature is satisfactory. With most fungicides used today, it is important to have the spray material on the foliage and fruit prior to the rainy period in order to prevent the spores from germinating. If in case of apple scab, the disease has made considerable headway, it may be advisable to use a more caustic spray such as liquid-lime sulfur to "burn out" the established fungus.

Typical spray schedules from leading fruit states are presented on the following pages. These are given only as an illustration and not as a guide because spray schedules vary considerably from one region to the next and for various fruits within a region. Also, they vary for the same region in different years, depending upon climatic conditions and upon the possibility of certain epidemics of diseases and insects which in most years are of minor importance. In these schedules, lead arsenate is given in terms of the powdered form, flotation sulfur as a paste, lime-sulfur as a liquid, and wettable sulfur as a powder. Nicotine is referred to as 40 per cent nicotine sulfate.

Peach Spray Schedule

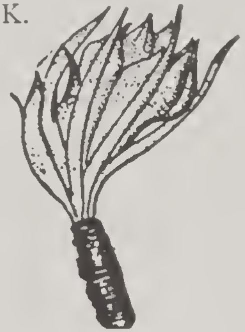
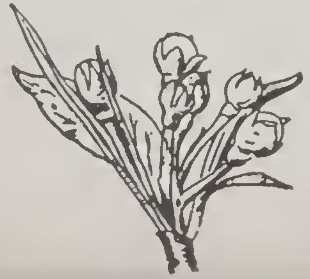
(For New York State as recommended by New York State College of Agriculture, Cornell Extension Bull. 473. 1945.)

Under New York conditions, the peach suffers severely from the attacks of three diseases—leaf-curl, brown rot, and scab—and, in certain localities,

TABLE 25

PEAR SPRAY SCHEDULE FROM MICHIGAN STATE COLLEGE, 1946

(MICHIGAN AGRICULTURAL EXTENSION BULLETIN 154)

APPLICATION	MATERIALS	TO CONTROL	EXPLANATIONS
1. DORMANT. Apply with the first good spraying weather in March or early April.	Oil emulsion, 3% heavy oil, or a commercial oil spray.	Psylla, scale insects, and mites.	For the control of pear psylla use an oil spray as an early spring application before egg laying begins. Apply with the first good spraying weather.
2. DELAYED DORMANT, or PREPINK. 	Bordeaux, 3–8–100.	Scab, leaf-blight, and curculio.	This application is good insurance on all susceptible varieties.
3. PINK. Apply when the buds have separated in the clusters but before the blossoms have opened. 	Bordeaux, 3–8–100 and lead arsenate, 3 lb. in each 100 gallons	Scab, leaf-blight, curculio, and bud moth.	This application should always be made in districts where scab is prevalent and everywhere on varieties such as Flemish Beauty. In many parts of the state, however, scab is seldom serious on most varieties. In such cases measures for its control may not be necessary.

4. PETAL-FALL or CALYX. Apply when most of the petals have dropped and after bees have quit working in the bloom.	Bordeaux, 2–8–100 and lead arsenate, 3 lb. in each 100 gallons of spray.	Scab, leaf-blight, codling moth, curculio, and other chewing insects.	

This Schedule Will Make Residue Removal Necessary.

5. FIRST COVER. Two weeks after petals fall.	Bordeaux 2–8–100, and lead arsenate, 3 lb. in each 100 gallons of spray.	Codling moth, curculio, other chewing insects, scab, and leaf blight.	Bordeaux may be omitted if scab and leaf-blight are not present.
5a. SECOND COVER. Two weeks after Application 5.	Lead arsenate, 3 lb. and water to make 100 gallons. *or* DDT ¾ lb.	Codling moth and curculio.	WARNING. IMPORTANT. Govern the use of lead arsenate during the summer by the prevalence of codling moth. DDT will not control pear psylla. HETP (Hexaethyl tetraphospate) will kill pear psylla.
5b. THIRD COVER. Two weeks after Application 5a.	Lead arsenate, 3 lb. and water to make 100 gallons. *or* DDT ¾ lb.	Codling moth and curculio.	
6. SUMMER GENERATION. Time determined the same as for apples.	Lead arsenate, 3 lb. and water to make 100 gallons.	Codling moth and curculio.	Bordeaux may be used at this time on varieties very susceptible to scab.

from the ravages of the plum curculio. The oriental fruit-moth is now well established in the State, and no method of control by spraying has been devised. (DDT has shown considerable promise against this insect in recent years. State experiment stations should be contacted for information.)

Spray Outline for Peaches

Leaf-curl spray (After the leaves drop in the fall or in the spring before the buds swell)

Lime-sulfur	6½ gallons
Water to make	100 gallons

If San José scale is present, 11 gallons of lime-sulfur should be used. Instead of lime-sulfur a 6-6-100 Bordeaux mixture may be used in the fall or a 3-3-100 mixture in the spring if scale is not important. Elgetol at 2 quarts per 100 gallons has given excellent results in control of leaf-curl as a spring spray. Fall sprays are being tested.

Preblossom spray (When the blossoms show pink, or a little earlier if a rain period threatens)

Lime-sulfur	2 gallons
Water to make	100 gallons

or

Elemental sulfur (at manufacturers' directions)	
Water to make	100 gallons

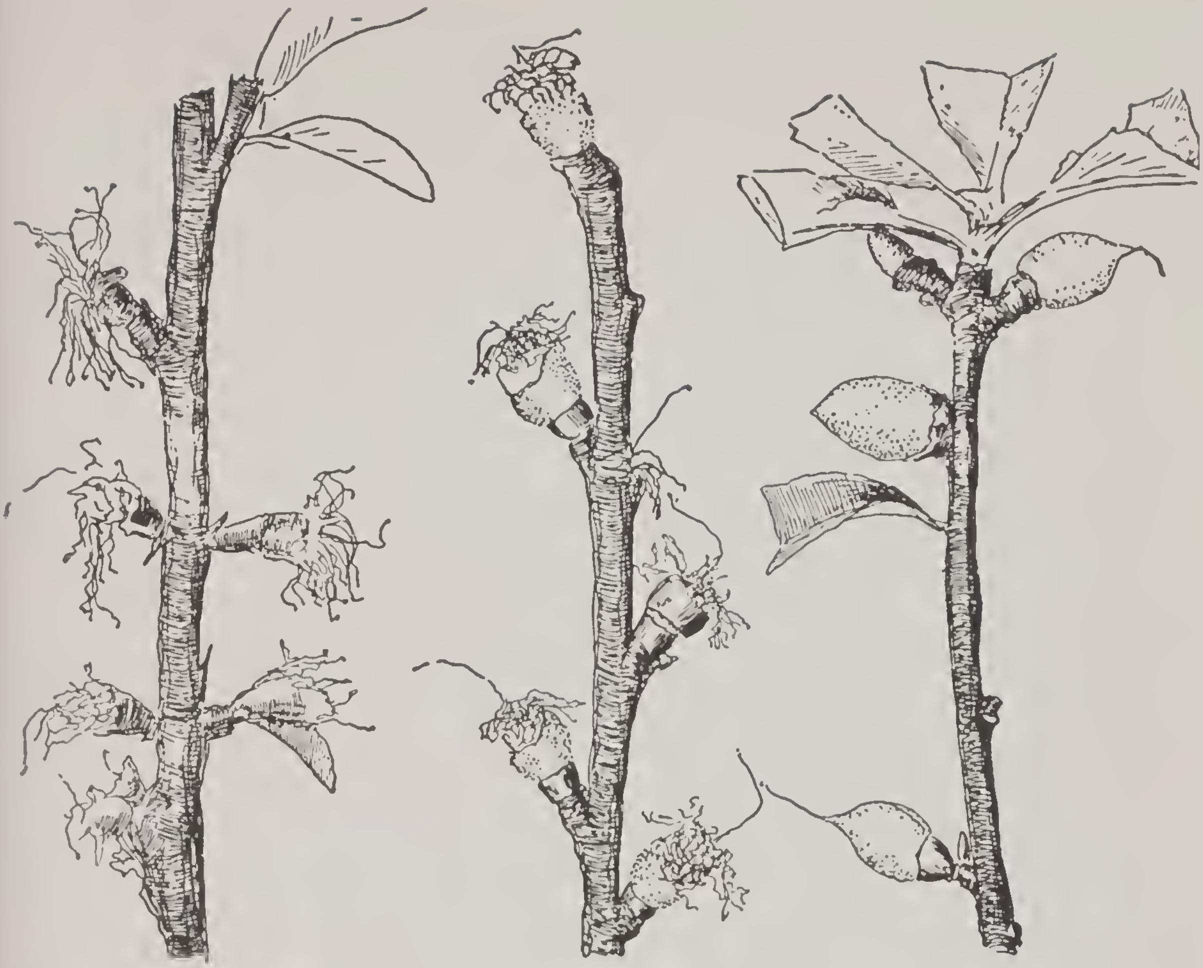
This application is made to prevent brown-rot blossom-blight.

If a dust schedule is followed, an application of dusting sulfur is indicated.

Shuck spray (When the shucks are falling from the fruits that are going to set) See Figure 204.

Elemental sulfur (at manufacturers' directions)	
High-calcium hydrated lime	16 pounds
Lead arsenate	2 pounds
Water to make	100 gallons

Zinc-lime may be substituted for the lime in the formula where arsenical injury has been serious in the past, using eight pounds of the crystals, or seven pounds of flakes, or five pounds of the monohydrated powdered zinc sulfate, with eight pounds of hydrated lime. Weaker strengths of zinc-lime prevent arsenical injury to the leaves but are inferior to 16 pounds of high-calcium lime or to the zinc-lime formula just given in reducing arsenical injury to peach wood. In the past few years, high-magnesium lime has been inferior to zinc-lime as an arsenical corrective. Until further tests have established the relative value of high-magnesium- and high-calcium-lime arsenical correctives, it seems advisable to use the high-calcium-lime which has always been recommended in this State and which has a satisfactory corrective value at 16 pounds when used with two pounds of the regular



John Wiley and Sons, New York

Figure 204. Important curculio peach spray is applied when shucks are falling (center twig).

acid lead arsenate per 100 gallons. Basic lead arsenate at the rate of three and five pounds per 100 gallons, with equal amounts of lime, has caused significantly less arsenical injury than has the acid lead arsenate with either lime or zinc-lime as a corrective. In 1944 tests in the southern Hudson Valley, the control of plum curculio with basic lead arsenate was substantially the same as with the acid form. The summer, however, was unusually dry and the curculio population was decreased by the total crop failure in 1943. Until further tests are made it seems advisable to limit the use of basic lead arsenate to the first spray when two arsenical sprays will be applied, except in areas where the plum curculio has not been a serious pest in the past. In the heavily infested areas, either one or two arsenical sprays may be needed, depending on weather conditions, bud development, and curculio activity. The first spray should be withheld until maximum temperatures of 80° F. are forecast. If these temperatures arrive and a spray is applied before many of the shucks fall, a second arsenical spray will be required as the last of the shucks are falling. If the high temperatures do not arrive until most of the shucks have fallen, only one arsenical spray will be needed. The single spray when feasible would reduce not only material and labor cost, but the danger of serious arsenical injury below that of two arsenical applications.[1]

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[1] Benzene hexachloride is showing good curculio control but some forms tend to give an undesirable odor and flavor the fruit under some conditions, particularly when the fruit is cooked.

TABLE 26

INSECTICIDE AND FUNGICIDE DILUTION TABLE FOR SPRAYING SMALL PLANTINGS.

(From Ohio Agr. Exp. Sta. Bull. 655. Revised 1947.)

WHERE AND WHY?	RECOMMENDED MATERIAL	AMOUNTS TO USE TO MAKE THE FOLLOWING QUANTITIES OF SPRAY (T = tablespoon, t = teaspoon)						
		1 Qt.	1 Gal.	3 Gals.	5 Gals.	10 Gals.	20 Gals.	100 Gals.
Dormant Fruit Trees and Ornamentals For: Scale and Red Spider	2% oil	4 t.	5 T.	1 cup	1½ cups	1½ pts.	3 pts.	2 gals.
	3% oil	5 t.	½ cup	¾ pt.	1¼ pts.	2½ pts.	2½ qts.	3 gals.
	4% oil	1½ T.	⅔ cup	1 pt.	1½ pts.	1½ qts.	3¼ qts.	4 gals.
	5% oil	2 T.	1 cup	1¼ pts.	2 pts.	2 qts.	1 gal.	5 gals.
Summer Sucking Insects on Flowers and Shrubs	Nicotine or Pyrethrum 1 to 200	1 t.	4 t.	4 T.	6½ T.	¾ cup	1½ cups	2 qts.
	1 to 300	⅔ t.	2½ t.	2½ T.	4¼ T.	½ cup	1¼ cups	1½ qts.
	1 to 400	½ t.	2 t.	2 T.	3¼ T.	6½ T.	¾ cup	1 qt.
	1 to 500	—½ t.	1½ t.	1½ T.	2½ T.	5 T.	⅔ cup	1½ pts.
	1 to 800	¼ t.	1 t.	3 t.	5 t.	3¼ T.	7 T.	1 pt.
Summer Chewing Insects on Tree Fruits, Small Fruits, Flowers, and Shrubs	Calcium Arsenate Lead Arsenate Spray Lime		2 T.	6 T.	10 T.	1¼ cups	2½ cups	3 lbs.
	Derris or Cube Powder		3½ T.	10 T.	1 cup	2 cups	4 cups	5 lbs.
Summer Diseases: Scab, Brown Rot, Leaf Spots, Blotch, Etc.	Dry-lime sulfur or	Post Bloom Sprays		10 T.	1 cup	1 pt.	1 qt.	5 lbs.
	Wettable sulfur			12 T.	1¼ cups	1¼ pts.	1¼ qts.	6 lbs.
	Commercial Bordeaux			According to directions on container				
Summer Cherry and Plum Leaf Spot	Fixed Copper (on basis of 50% metallic) plus			3 T.	5 T.	10 T.	1¼ cups	1½ lbs.
	Fresh Spray Lime			6 T.	10 T.	1¼ cups	2½ cups	3 lbs.
Peach Leaf Curl	Dry-lime sulfur (dormant spray)			¾ lb.	1¼ lbs.	2½ lbs.	5 lbs.	25 lbs.

Summer sprays (The first spray, two or three weeks after the shucks have fallen; the second spray, two or four weeks before the fruit ripens)

Elemental sulfur (at manufacturers' directions)	
Water to make	100 gallons

These sprays are applied for the control of brown rot and scab.

If a dust schedule is followed, an application of dusting sulfur is indicated.

SPRAY CALENDAR FOR CHERRIES

(FROM BULLETIN 131, JAN., 1946, "INFORMATION FOR VIRGINIA FRUIT GROWERS," VA. POLYTECHNIC INSTITUTE EXT. SERVICE)[1]

No.	TIME OF APPLICATION	MATERIAL FOR 100 GAL. OF SPRAY	PURPOSE
1	Dormant season.	Lime-sulfur, 32° Baumé, 12 gallons; or 3% oil.	Scale
2	Immediately after petals fall.	Lime-sulfur, 32° Baumé: On *Sour Cherry,* 8 quarts, On *Sweet Cherry,* 6 quarts, add 2 pounds lead arsenate and 3 pounds lime to each 100 gallons of solution.	Leaf spot Curculio Brown rot
3	One week after petal fall or when ⅔ of shucks have fallen.	Same as No. 2.	Leaf spot Curculio Brown rot
4	First cover; two weeks after No. 3.	Same as No. 2.	Leaf spot Curculio Fruit fly Brown rot
5	Second cover; two to three weeks after No. 4 when fruit is coloring.	Bordeaux mixture 1½–3–100 or an insoluble copper 2 pounds plus lime 3 pounds.	Leaf spot Brown rot
6	Immediately after fruit is harvested.	Same as No. 5.	Leaf spot

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[1] Developed as a result of several years co-operative research in Pennsylvania, West Virginia, and Virginia and now used in these states.

SPRAY PROGRAM FOR PRUNES AND PLUMS IN OREGON

(From Oregon Ext. Bull. 664. 1946.)

TIME OF APPLICATION	INSECT OR DISEASE	SPRAY MATERIAL AND STRENGTH
1. Dormant spray. As winter buds are ready to open.	San José scale. Lecanium scales and mite eggs.	An oil emulsion to give 4 per cent actual oil, or lime-sulfur 3 gallons plus oil 2 gallons to 100.
	Brown rot.	Cultivate to destroy spore cups on ground.
2. Delayed dormant spray. When first few buds show green tips.	Thrips If no thrips are present delay spray to green tip and preblossom applications.	Lime-sulfur 3 gallons to 100 and nicotine sulfate 1 pint to 100 gallons of water, or 20 per cent DDT in miscible oil, 1 pint to 100.

(*Continued on following Page*)

SPRAY PROGRAM FOR PRUNES AND PLUMS IN OREGON

(From Oregon Ext. Bull. 664. 1946.)

TIME OF APPLICATION	INSECT OR DISEASE	SPRAY MATERIAL AND STRENGTH
3. Green-tip spray. Most of buds green at tip.	Thrips.	Same as No. 2.
4. Preblossom spray. Buds white just before opening.	Brown-rot.	Cultivate to destroy spore cups on ground.
	Bud moth. Syneta beetle. Twig miner.	Lead arsenate 4 pounds plus hydrated lime 2 pounds to 100 gallons.
	Aphids.	Nicotine sulfate 1 pint to 100 gallons, plus spreader.
5. First fruit spray. As soon as shucks fall.	Leaf spot and brown rot.	Use wettable sulfur spray, 6 pounds to 100 gallons; or sulfur dust.
6. Later sprays or dusts. (Western Oregon). Beginning about 5 weeks before harvest, repeat weekly up to a few days before harvest.	Leaf spot and brown rot.	Apply spray or dust (as in 5).
7. Later sprays (Eastern Oregon)	Pacific mite. Rust mite.	Lime-sulfur 1–2 gallons per 100 according to temperature, when mites appear. (See County Agent.)

PROGRAM FOR YOUNG NONBEARING FRUIT TREES

Early in the dormant season, young trees should be inspected for scale insects, aphid eggs, and red mite eggs. If evidence of these insects is found, the trees should receive the dormant oil spray recommended for bearing trees of the same sort. Sour cherry trees rarely require dormant spraying. Young peach trees should receive annually a dormant liquid-lime sulfur or a Bordeaux spray for leaf curl.

Young apple trees in regions where scab is a problem should receive at least one spray in the late prebloom period for apple scab. In spring when scab is serious, another spray should be applied at the first cover application, as recommended for bearing trees. If young apple trees have become heavily infested with green aphis during the growing season, it may be desirable to control them with nicotine sulfate, as recommended in standard spray schedules for mature trees.

During the prebloom period, careful inspection should be made of the foliage for young cankerworms (sometimes called measuring worms). If present, a lead arsenate spray should be applied along with the sulfur fungicide, as often recommended for the pink spray for bearing trees. If the young orchard is near a woodland infested with cankerworms, an additional spray of the calyx-cup formula may be necessary when about three-quarters of the blossom petals have fallen.

It is not uncommon for tree hoppers to seriously damage the trunks and branches of young trees by making one-fourth-inch slits in the bark in which eggs are laid. This is particularly true if the cover crop is alfalfa, soybeans, cowpeas, or sweet clover. Clean cultivation or frequent mowing of the cover crop until about the first of July of each year should help reduce the damage considerably.

Young cherry trees should be sprayed for leaf spot and slugs, as recommended for mature trees in order to keep the foliage healthy and the trees growing normally.

In early September, young peach trees should be examined for peach tree borers which are white grublike worms that work in and under the bark just above and below the ground surface. Inspection should also be made in April. If present, the borers can be removed by careful use of a knife. Gassing with paradichlorobenzene or ethylene dichloride is commonly recommended for large-scale treatments.

Special precautions are necessary among all young fruit trees in years when the periodical cicada (17-year locust) is due to appear. It may be necessary to enclose the entire treetops with cheesecloth for a period of about six weeks in early summer. Specific dates can be secured from the entomologist at the local state experiment station. This practice is especially needed for young trees located near old apple trees or woodlands which have maintained a heavy brood of cicadas in previous years.

SPRAY AND WEATHER INJURY

Spray and weather injury to leaves and fruit are frequently confused. It may be necessary to examine neighboring unsprayed trees before the relative amount of spray injury can be determined on sprayed trees. Spray injury develops when improper materials have been employed or when the correct materials have been applied in the wrong way, or when certain weather conditions tend to increase spray injury. Weather injury results from exposure of the fruit to extremes of temperature or moisture. Apple varieties vary greatly in susceptibility to spray injury and diseases as shown in the following table 27.

Trees low in vigor are frequently injured more by spray and weather conditions than moderately vigorous trees. Also, foliage which has been injured by insects, diseases, wind whipping, or hail, is more susceptible to spray injury than healthy foliage.

Lime-sulfur injury. It is well known that liquid-lime sulfur will burn most foliage and small apples if the spray is applied during hot weather or in strong concentrations, or under weather conditions resulting in slow drying of sprays. Lime-sulfur injury is characterized by deforming, edge-burning, crimping, and scalding of the leaves. Foliage may be dwarfed in size

TABLE 27

DEGREE OF SUSCEPTIBILITY OF APPLE VARIETIES TO DISEASES AND SPRAY INJURY

(From Ohio Agr. Exp. Sta. Bull. 655, Revised 1947)

Variety	Scab	Bitter Rot	Blotch	Brooks Spot	Fire Blight	Cedar Rust	Bordeaux Russet	Lime-Sulfur Russet
Baldwin	Moderate	Moderate	Slight	Slight	Slight	Slight	Very	Very
Ben Davis	Very	Very	Moderate	Slight	Slight	Slight	Very	Very
Cortland	Very	Very	Very	Slight	Very	Moderate	Slight	Slight
Delicious[1]	Very	Moderate	Slight	Moderate	Slight	Moderate	Slight	Moderate
Duchess	Moderate	Slight	Very	Slight	Slight	Slight	Slight	Slight
Golden Delicious	Slight	Very	Moderate	Very	Slight	Slight	Very	Very
Grimes	Slight	Very	Slight	Very	Very	Slight	Very	Very
Jonathan	Slight	Very	Slight	Very	Very	Moderate	Very	Moderate
McIntosh	Very	Very	Very	Slight	Slight	Slight	Slight	Moderate
N. Spy	Very	Moderate	Slight	Slight	Slight	Slight	Slight	Slight
R. I. Greening	Moderate	Very	Slight	Slight	Very	Slight	Moderate	Moderate
Rome	Very	Moderate	Moderate	Moderate	Moderate	Very	Slight	Slight
Stayman	Moderate	Moderate	Slight	Moderate	Slight	Slight	Moderate	Moderate
Wealthy	Moderate	Slight	Slight	Slight	Very	Moderate	Slight	Slight
Winter Banana	Very	Very	Slight	Slight	Slight	Moderate	Moderate	Moderate
Yellow Transparent	Moderate	Slight	Slight	Slight	Very	Slight	Slight	Slight

[1] Varieties like Delicious, Rome, Stayman, etc., include the red sports of those varieties.

both during the early and later stages of development. This results in reduced leaf area, reduced fruit size, and poor quality and finish of the fruit. Foliage crimping and dwarfing are also caused by low temperatures in early stages of leaf development.

Within recent years, it has been shown that even very dilute lime-sulfur sprays, such as 1 to 100, may markedly reduce the photosynthetic activity of apple leaves. Older trees are usually affected more than trees 10 to 15 years of age. Liquid- or dry-lime sulfur are not considered safe for summer spraying of peaches. The wettable sulfurs are preferred under these conditions.

Bordeaux injury. Russeting is a characteristic injury of Bordeaux mixture on apples. Very susceptible apple varieties are Grimes Golden, Golden Delicious, Jonathan, Baldwin, Ben Davis, Gano, and Ensee. Varieties comparatively resistant to russet injury are Rome Beauty, Gallia Beauty, Delicious, Northwestern Greening, Duchess, and Wealthy. Most russeting is caused by applications of Bordeaux in the preblossom, petal-fall, and ten-day sprays. The chances for russeting continue until about six weeks after petal fall in northern climates.

Cool wet weather is most inducive to Bordeaux injury, which results in slow drying of the spray. The best time to spray with Bordeaux is when the trees are dry and the weather favors quick drying of the spray material on the trees. High temperatures tend to reduce Bordeaux injury. Occasionally, Bordeaux spraying may be associated with premature defoliation of the trees, especially following a dry period. This type of injury can be reduced by using a weak Bordeaux mixture such as 2-4-100. Stronger Bordeaux mixtures should be used only in case of such diseases as bitter rot.

Arsenical injury. Peaches are the most susceptible to arsenical injury, especially when acid lead arsenate is used alone or combined with sulfur fungicides. Leaf damage may appear in two ways: (*a*) The leaves may exhibit many small injured areas, giving a general "shot hole" appearance; or (*b*) They may turn yellow and drop prematurely, or both. Tender peach twigs are injured most, especially in areas where the spray material tends to accumulate, such as at the base of leaf petioles and in crotches. As the wood ages, scaly bark may develop from this injury. Fruit may be injured both directly and indirectly. Arsenical injury to the foliage and wood reduces food manufacture by the leaves which in turn reduces fruit size, results in poor quality and color, and some fruits may drop prematurely. Arsenical injury on the fruit appears as cracks and gummy exudations.

Basic lead arsenate is used in place of acid lead arsenate in some states to control curculio on peaches. Arsenical injury is practically negligible with basic lead arsenate, but there is some doubt if it adequately controls curculio. It is used at the rate of four pounds to 100 gallons of water, with an equivalent amount of lime. In New Jersey, 16 pounds of lime are used with two pounds of acid lead arsenate in 100 gallons of water for peaches. It is claimed that the high-lime content not only repels the curculio, but also reduces arsenical injury to a minimum. In most eastern states, acid lead arsenate is used on peaches in only one application at the shuckfall period when it is combined with zinc sulfate and lime. Both of the latter chemicals act as safeners for the acid lead arsenate.

Apple foliage may be injured in two ways by arsenical sprays: (1) tip and marginal burning which may result from an accumulation of arsenic at the margins and tips of the leaves, and (2) a yellowing of the foliage due to absorption of the arsenic by the leaves or by injury to the petiole. In extreme cases of burning, the damage may result in almost total defoliation.

Arsenical injury on apple fruit appears as blackened areas around the calyx end, which later becomes sunken. Secondary rots tend to develop in these injured areas. Arsenical burning on apples can be prevented by the addition of excess lime, or zinc sulfate and lime, to the lead arsenate sulfur combination. The finish of the fruit is usually improved where excess lime is added.

Zinc sulfate has been used widely with good success in combination with lime to prevent arsenical injury on nearly all commercial apple varieties. Weak bordeaux mixture (½-2-100 formula) is also used as a corrective for arsenical injury in sprays applied 6 weeks or more after the petal-fall stage on all apple varieties except Golden Delicious and Grimes Golden.

Weather injury. Low temperatures and frost during the blossoming period and early part of the growing season may cause varying amounts and kinds of russet injury to fruits. This injury usually takes the form of a belt of russet around the apple. Weather injury to the leaves is characterized by dwarfing, crimping, and when severely injured, blisters may develop on the under surfaces. Such leaves may turn yellow and drop prematurely. During extremely hot days in midsummer, exposed fruit may show sunburning on one cheek. A discoloration of the skin is evident and in extreme cases blistering and cracking of the skin may occur on the exposed areas. Very hot weather may also cause a bronzing of the red color and a whitening of the green color of the fruit.

Mechanical injury. Mechanical injury to the foliage and fruit results from improper use of spray guns. Injury consists of russeted fruit, dwarfed or torn leaves, and in some cases a lack of finish and quality of the fruit. Mechanical injury is caused by (1) poor breakup of the liquid at the nozzle, (2) coarse particles in the spray materials, and (3) drenching of the foliage.

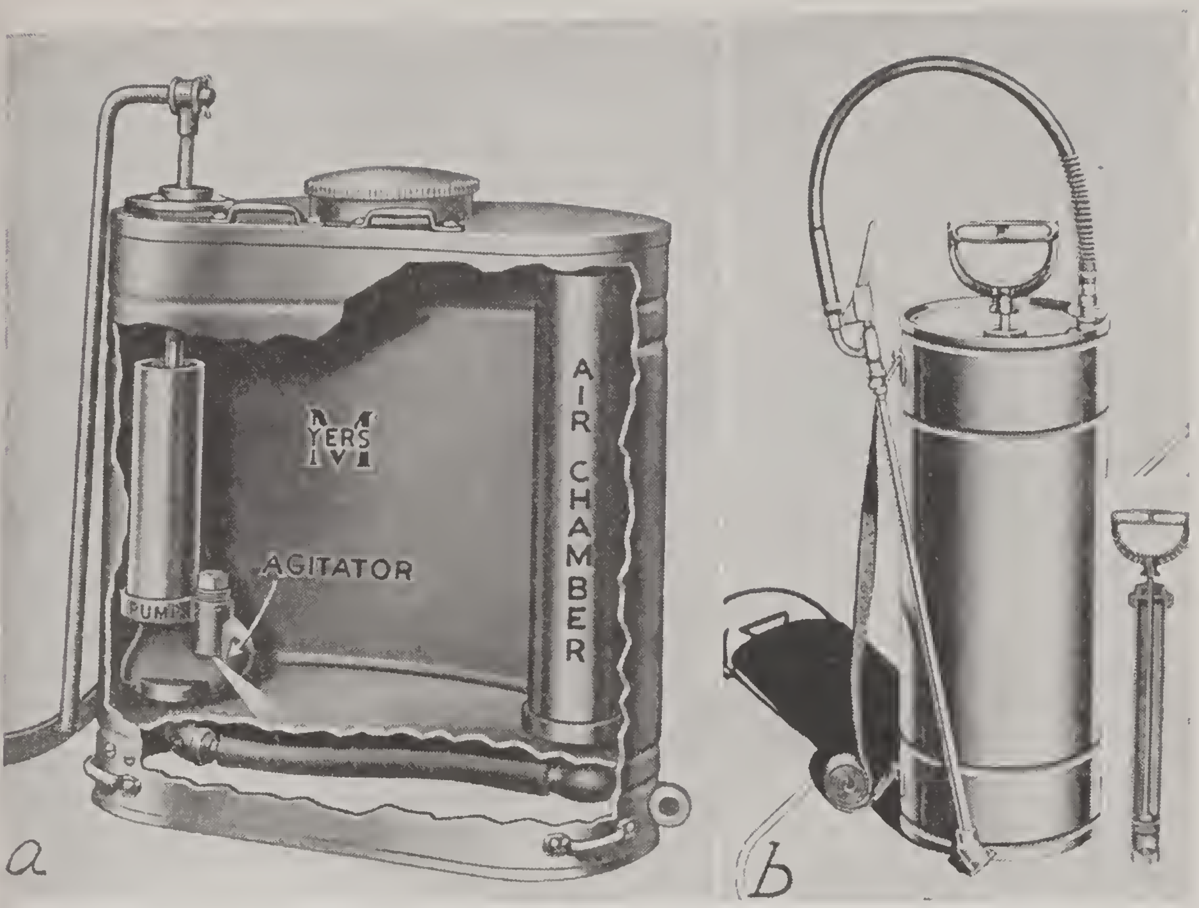
Importance of lime in preventing spray injury. The main purpose for lime in summer sprays is to prevent spray injury. It also may serve as a guide to the spray operator to see where the foliage is thoroughly covered with spray materials. Freshly manufactured hydrated lime is preferred which is free from grits and is so finely divided that 99 per cent of the particles will pass through a 325-mesh sieve; all particles should pass through a 300-mesh sieve. Lime kept over 90 days in the spray shed should be added to the soil and not used for spraying purposes. A supply of specially hydrated spray lime obtained in the spring should be satisfactory throughout the season.

SPRAY MACHINERY AND EQUIPMENT

There are three fundamental requirements for good spray equipment: (1) obtain a complete spray coverage of the tree or plant; (2) apply the spray materials during the most effective period, and (3) obtain these results at the lowest cost possible. There is no set method of application and no one piece of equipment which will assure these results for all growers. A satisfactory method and piece of equipment for one set of conditions may be entirely unsatisfactory for another set. In order to make a wise choice of equipment to suit his conditions, the grower must have a fundamental knowledge of different types of spray equipment, their advantages and limitations, and know how to operate them for best insect and disease control.

BASIC MECHANICS OF SPRAYERS

Spray atomization. It is the purpose of all sprayers to atomize a liquid with or without solids into small droplets and to force this finely divided spray onto the plants, fruit, or leaf surfaces. Adequate coverage should be obtained with a minimum of material. The most common method of atomizing liquid sprays is by direct hydraulic pressure which forces the liquid rapidly through a nozzle, causing it to disintegrate into minute droplets. Another more or less opposite means of producing sprays is to use a



F. E. Myers and Bros. Co., Ashland, Ohio

Figure 205. (a) The knapsack sprayer (diaphragm-type) is carried on the back of the operator with straps over the shoulders. The operator pumps continuously and an air chamber provides an even flow of solution from the nozzle. (*b*) The compressed-air knapsack sprayer holds from two and one-half to four gallons. The tank is filled three-quarters full of solution and the air compressed to 50 to 75 pounds. It is necessary to stop spraying and pump at intervals in order to keep up pressure. Cross-cut of pump unit is shown at lower right.

high-velocity air stream which picks up a jet of liquid or a coarsely atomized liquid and deposits it in a fine mist on the plant.

Types of pumps. All spray pumps are essentially similar in basic principles with the exception of pumps used with knapsack sprayers of the compressed air and diaphragm type. Knapsack sprayers of the compressed-air type contain a simple air-displacement pump inside a small cylindrical tank (Figure 205). The tank is filled about three-quarters full of spray, the lid replaced, and the air within the tank compressed with the hand pump to a pressure of 50 to 75 pounds per square inch. When the spray nozzle is opened, the air pressure forces the liquid through the nozzle. The chief disadvantage of the compressed-air knapsack sprayer is the fact that the spray pressure will decrease as the liquid level decreases and the air expands. Therefore, these sprayers are unsuitable where a uniform spraying pressure is desired.

The knapsack sprayers which have constant pressure pumps are of two types, plunger and diaphragm, both of which are of the positive-displacement type (Figure 205). These pumps are fitted with a small air-cushion chamber within the tank to maintain uniform pressure. With this type sprayer, it is not necessary for the tank to withstand any pressure because the pump may be mounted either on the inside or the outside of the tank. The tank serves only as a reservoir of spray solution for the pump. The equipment is mounted on the sprayman's back and he must pump slowly but continuously while spraying. The pump maintains a more or less uniform pressure of from 50 to 75 pounds per square inch. Knapsack sprayers are suitable only for low-growing crops.

The type of pump used in power sprayers is of the displacement single-acting reciprocating type, examples of which are shown in Figure 6. They are available in a wide range of sizes and capacities with working pressures up to 1000 pounds per square inch or higher (Table 28). The capacity of these pumps depends upon: (1) the number of cylinders; (2) diameter of each cylinder; (3) length of stroke; (4) number of strokes of plunger per unit of time; and (5) the volumetric efficiency of the pump.[1] All spray rig manufacturers rate pumps according to their maximum capacity in gallons per minute at a given pressure. With very little leakage past the valves or

TABLE 28

SIZE OF PUMP TO PURCHASE FOR GIVEN QUANTITIES OF SPRAY PER APPLICATION

(After Ohio Agr. Exp. Sta. Bull. 655. Revised 1947.)

SPRAY MATERIAL REQUIRED FOR ONE APPLICATION	PUMP SIZE REQUIRED IN GALLONS PER MINUTE ON PORTABLE RIGS
Less than 500 gallons	Hand pumps
500 to 3000 gallons	Power pumps rated up to 10 gallons
3000 to 6000 gallons	Power pumps rated at 12–15 gallons
6000 to 10,000 gallons	Power pumps rated at 15–22 gallons
Above 10,000 gallons	Power pumps rated at 35 gallons or more according to need

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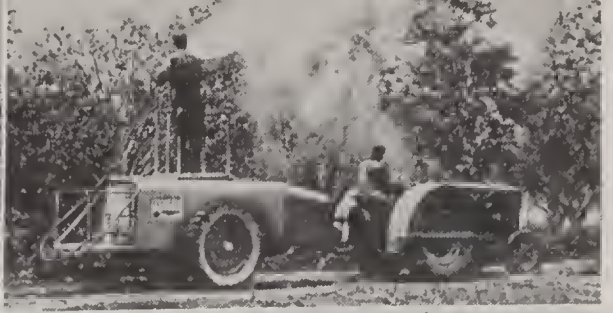
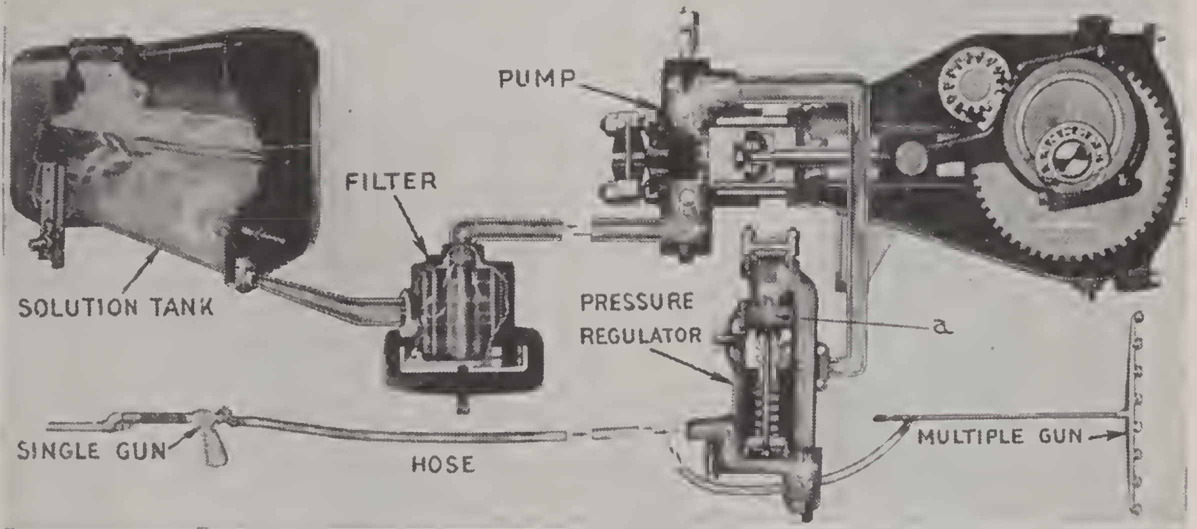
[1] This is defined as the actual volume of spray discharged divided by the plunger displacement.

(Top three) H. G. Ingerson, John Bean Mfg. Co., Lansing, Mich. (Middle left) Hardie Mfg. Co. (Middle right) F. E. Myers Bros. Co. (Bottom) Friend Mfg. Co.

Figure 206. (Top left) Orchard spray rig complete with pneumatic rubber tires, 500-gallon spray tank, pump, and auxiliary engine, pulled by either team or tractor. (Top right) Power take-off sprayer attached to tractor. These outfits are becoming increasingly popular with growers. (Middle) Channels through which spray solution flows from solution tank through the filter, the pump, the pressure regulator, and out through a single nozzle gun (left) or multiple nozzle boom gun (right). When nozzles are shut off, spray solution by-passes from pressure regulator back to tank (return pipe at a to tank not shown). (Middle left) A 3-cylinder vertical-type spray pump, showing crank shaft and connecting rods. Inlet and outlet ball valves are housed on either side of base of each cylinder. (Middle right) Horizontal-type pump with eccentric drive shown at *a*, connecting-rod drive and removable rubber-fabric plunger-cup packing at *b*, porcelain cylinder walls at e, inlet valve at c, and outlet valve at *d*. (Bottom) Spray pump using Scotch-yoke drive at a to which horizontal opposing plungers are attached. In operation yoke moves back and forth. At *b* the stationary outside-type packing for cylinders is shown. Spray inlet-ball valve is shown at c and outlet valve at *d*.

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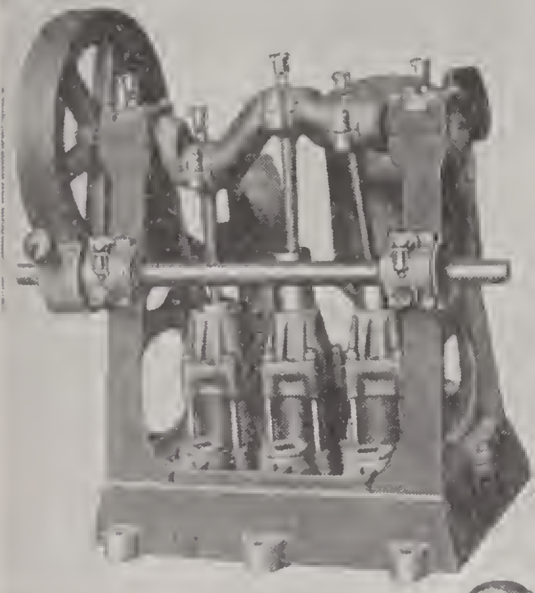

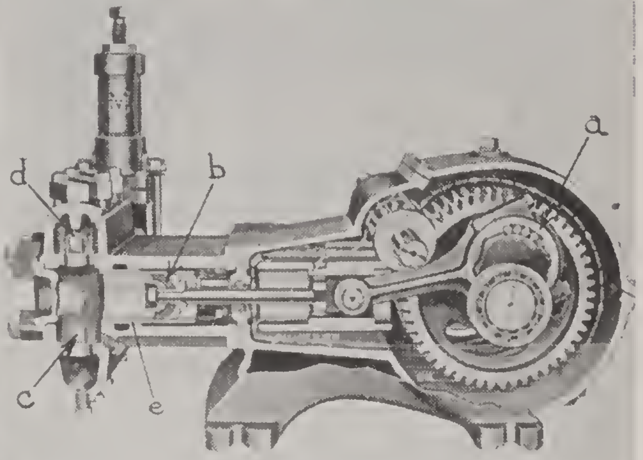
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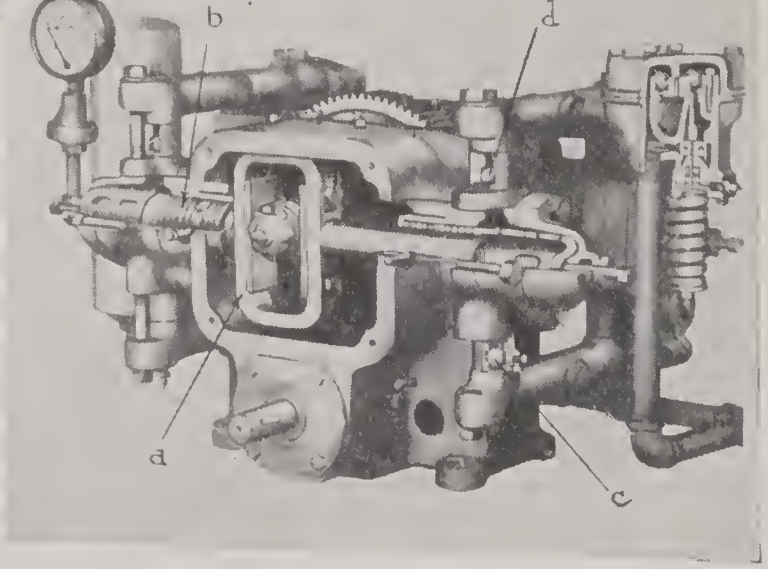
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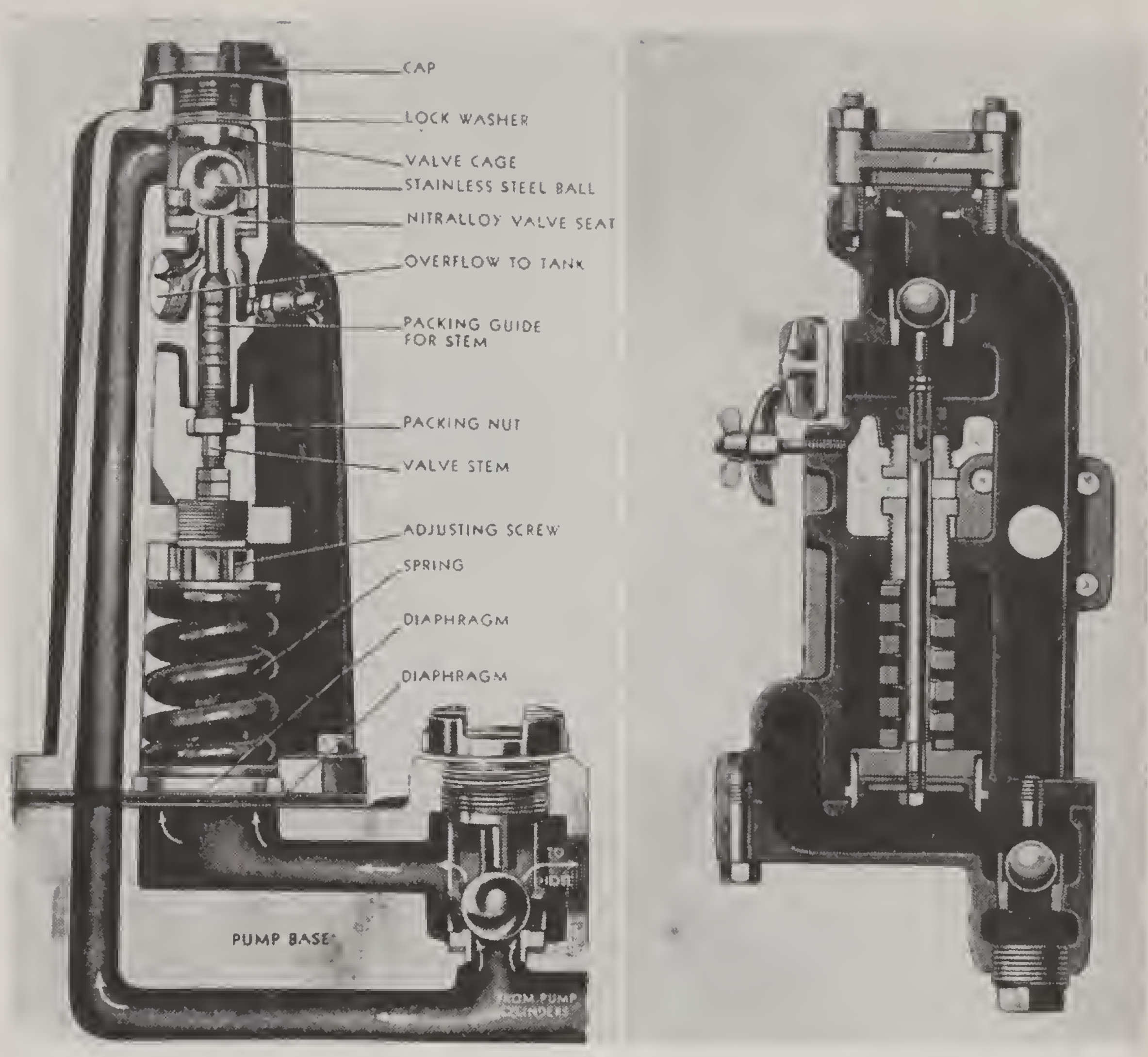


Hardie Mfg. Co. and John Bean Mfg. Co., Lansing, Mich.

Figure 207. Two types of pressure regulators far power sprayers. (Left) Rubber fabric diaphragm-type regulator; when salution pressure on diaphragm exceeds pressure desired, spring raises the valve stem which in turn lifts ball and allaws salutian to by-pass under ball and back ta spray tank. (Right) Pressure regulator of the plunger-type which atherwise aperates an same principle as regulatar at left.

plunger packings, the volumetric efficiency of reciprocating pumps on modern sprayers should be 90 per cent or more. During spraying, the pumps are under considerable strain and much research has been done in recent years to prolong the life of plunger packing, valves, and cylinder walls.

Valves. In small hand sprayers and dusters, the "poppet" air valve is commonly used. It usually consists of a leather flap held in place over the hole by a small spring. Under pressure the spring gives and the valve opens, allowing air to pass one way, but not the other. In the simplest type of poppet valve on dusters, no spring is ordinarily used. The flap is attached at the side of the hole, allowing the air current to pass one way.

Ball-type valves, usually of hardened stainless steel, are widely used in hand and modern power sprayers (Figure 207). Both the balls and valve seats are corrosion resistant. No gaskets are used with the modern valve seat assembly which eliminates a source of leakage formerly troublesome.

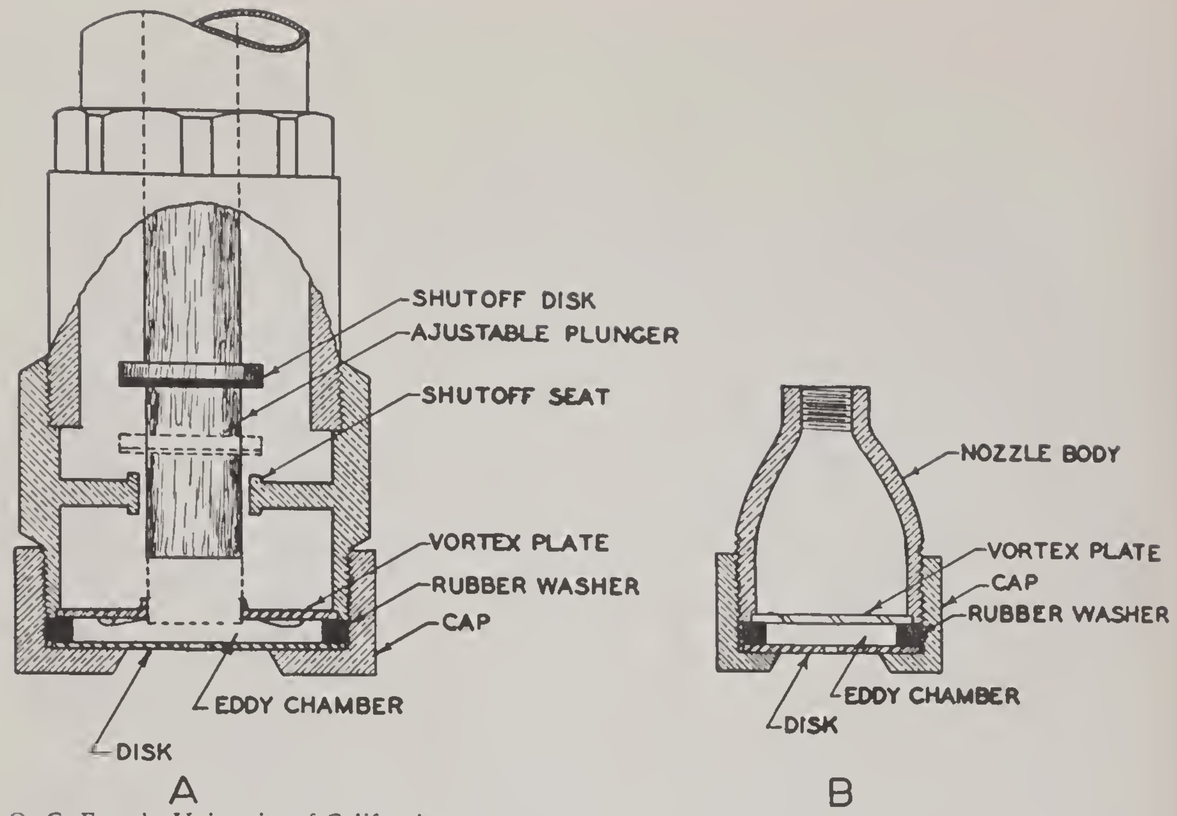
Plungers. There are two types of plunger-displacement mechanisms in use: (1) A plunger with an expanding cup fitted to the end of the plunger; thus, the cup moves with the plunger, as shown in Figure 206; and (2) a plunger which operates through a stationary packing which acts as the cylinder wall for the displacement chamber (Figure 206). Neither of these two systems is free from wear by abrasive chemicals manipulated under high pressure. On the pressure stroke, the plunger cups which are constructed of molded rubber and fabric, expand against the cylinder walls. This seals and prevents leakage past the cup. Although most cylinder walls are now coated with acid-resistant porcelain, there eventually is some abrasion and wear of the cylinder walls. When this occurs, even the new plunger packing will not entirely prevent leakage.

Plungers which operate through packing in the walls of the cylinders (Figure 206) are made of stainless steel, inasmuch as abrasion and erosion of the plunger must be avoided as much as possible to prevent leakage. The packing should be adjusted so that there is a very slight leakage which indicates that the packing is not so tight as to cause scoring of the plunger.

The reciprocating motion of plungers in modern spray pumps can be obtained by several different mechanisms, the most common of which are (1) crank shaft and connecting rods, (2) eccentric and connecting rods, and (3) the Scotch-yoke assembly (Figure 206). The Scotch-yoke assembly has two opposing plungers, operating from one reciprocating mechanism and, therefore, sprayers using this system must be either two or four cylinders. The other two systems usually involve three cylinders. It is immaterial whether the cylinders are vertical or horizontal.

In recent years, a special effort has been made to simplify maintenance by using high-grade metals and designing the valves and plungers for easy accessibility. Another improvement in spray machines is the enclosure of working parts to provide for self-oiling systems and to afford protection from dust. In purchasing a spray machine, it is important to consider the ease with which the pump can be taken apart and repaired.

The pressure regulator. Perfection of the pressure regulator by the Bean Spray Pump Company in 1914 was one of the biggest advances in spray machinery. In power sprayers, some type of automatic by-pass is needed to divert spray solution back to the tank when the spray nozzles are suddenly shut off but the pump continues to operate. In other words, the pressure regulator serves as a safety device. It also has two other functions: (1) to maintain a uniform pressure at the spray nozzles; and (2) to permit the pump to operate at a greatly reduced load when no material is being discharged through the nozzles. There are two principles upon which regulators operate: (1) a spring-loaded diaphragm or (2) a plunger (Figure 207). When in either of these types, the pressure of the liquid exceeds the resistance offered by the compression spring, the spring gives and lifts a rod which in turn lifts a ball valve and permits excess liquid to by-pass under the ball and through a pipe back to the supply tank (Figure 207). A

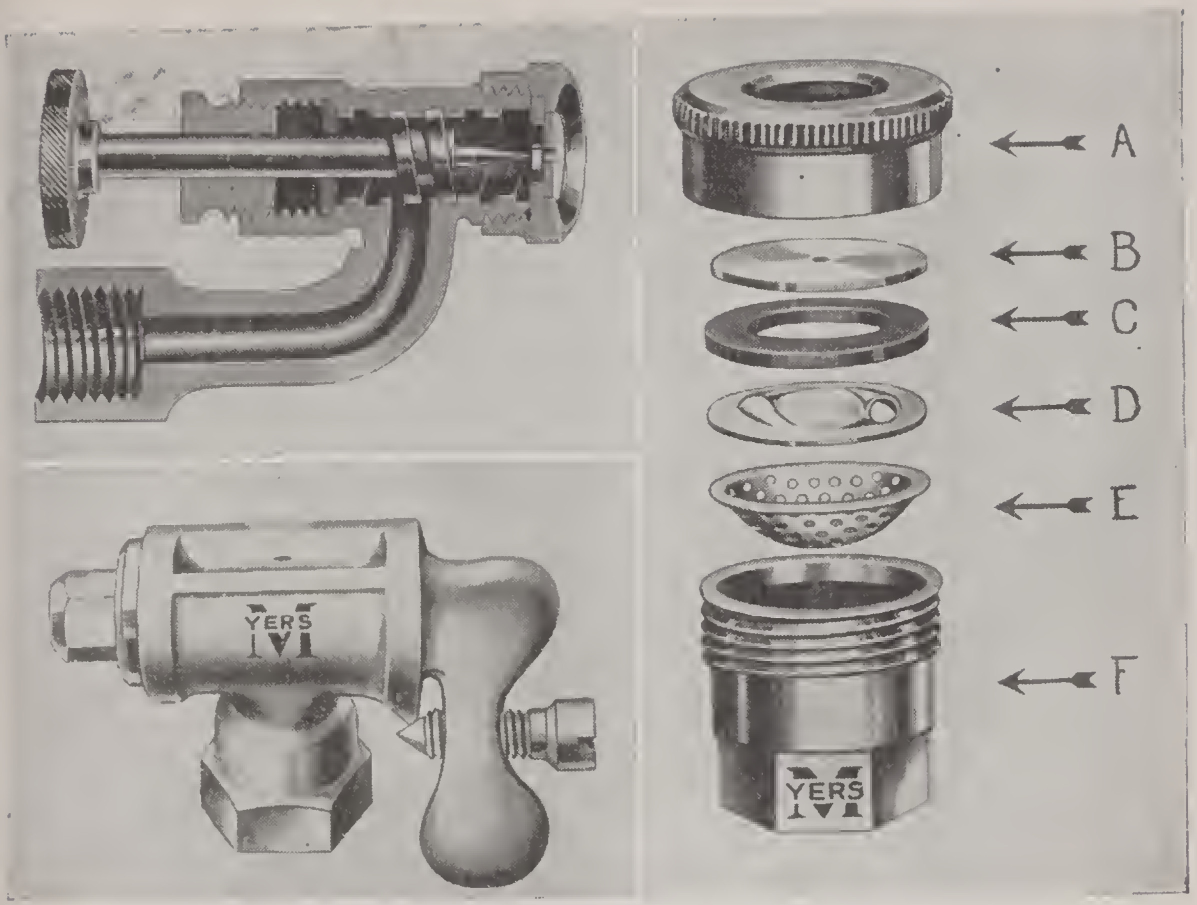


O. C. French, University of California

Figure 208. Two types of eddy-chamber on disk spray nozzles: *A*, variable-depth type used in spray guns, adjustable plunger regulates width of cone and fineness of spray; *B*, fixed-depth type of eddy-chamber nozzle found on multiple nozzle booms, or as a single nozzle on small-capacity sprayers.

check valve (Figure 207) is employed between the diaphragm or plunger and the pump discharge line to assist the pressure regulator in acting as an unloading device as well as a pressure release valve. The release-valve ball and check-valve ball must fit perfectly in their seats in order that they function sensitively. If the check valve were removed from the system, the pressure regulator would then function merely as a release valve. A spray machine is functioning properly when a little liquid is by-passing through the pressure regulator and going back to the supply tank while the spraying is in progress. If no liquid is by-passing back to the spray tank, the discharge of the spray guns is probably too great for the capacity of the spray pump, provided the pressure regulator is properly adjusted and the valves are not leaking.

Nozzles, guns, and brooms. Nozzles of the eddy-chamber type are most commonly used today on spray guns, rods, or multiple-nozzle brooms (Figure 208). Vermorel and Bordeaux nozzles also are frequently used on hand sprayers and a few power sprayers (Figure 209). The integral parts of the eddy-chamber or disk nozzles are shown in Figure 209. The spray solution under high pressure comes up against and passes through a vortex plate which contains spiral or tangental channels. These channels set up a whirl of the spray solutions in the eddy chamber. Purpose of this whirl is to rotate the spray stream to facilitate breakup after it is discharged through the disk orifice, or port. The angle of the spray cone can be changed to narrow or wide by varying the depth of the eddy chamber or the speed of rotation of



F. E. Myers and Bros. Co., Ashland, Ohio

Figure 209. (Tap left) Vermorel nozzle emits a variable fine spray mist by regulating the screw plunger. If the nazzle becames plugged, it can be disgarged with screw plunger. (Bottom left) Bardeaux nozzle thraws a fan-shaped mist ar a salid stream, or it may be shut off entirely by manipulating the cock handle and lock screw. Nozzle is unclogged by twisting the cock handle. (Right) Disk-type nazzles are the most papular; parts consist of: *A* cap, *B* stainless steel disk, *C* rubber gasket ar washer, *D* stainless steel vortex ar whirl plate, *E* brass cone strainer, and *F* body.

solution within it. A shallow chamber will produce a wide-angled cone. In case of a very deep eddy chamber, a jetlike spray stream will be emitted through the nozzle disk with considerable driving power and distance. With a single nozzle spray gun, the depth of the eddy chamber in the nozzle can be varied by means of an adjustable plunger, as shown in Figure 208. Thus, while spraying close to a tree, the cone is made wide and with less driving power by reducing the depth of the eddy chamber. On the other hand, if it is desired to spray the top of a tree several feet distant, the eddy chamber can be adjusted deeper to obtain a jetlike stream.

A spray cone may become unsymmetrical if the hole in the disk plate becomes irregularly worn, or if the vortex openings assume an unsymmetrical shape. It is, therefore, important to renew the spray disk or vortex plate when such a condition arises.

There are two types of spray patterns: (1) a ring type, or (2) a solid-pattern type. The solid cone is obtained by a hole arranged in the vortex plate so that it is in direct line with the disk hole.

Pressure effects. With present-day orchard power sprayers, pressures of 450 to 600 pounds are commonly used. In the majority of cases, this has proved advantageous as compared with the lower pressures of 250 to 400 pounds. Use of the higher pressures has speeded up spraying operations without requiring additional man hours of labor and without requiring any increase in the quantity of spray material, provided the spraying is handled properly. Under the higher pressures, the liquid is broken into finer droplets which give a more uniform coverage at a rapid rate. Under higher pressures, it is important that the operator be alert at all times in order to prevent wastage of spray materials. With respect to high pressures, however, it is interesting to note that a better deposit of arsenate can be obtained in the calyx-cup spray on apples by using a lower pressure of between 250 and 400 pounds. This is because the larger spray droplets traveling at low velocity tend to penetrate and remain in the calyx cups better than the finely atomized sprays thrown at high velocity.

The factors which influence spray nozzle operation are summarized as follows:[1]

Disk-orifice diameters affect:

1. Diameter of spray cone (the smaller the orifice the smaller the cone).
2. Carry (carrying distance increases with diameter).
3. Quantity of discharge.

Pump-pressure increases cause:

1. Smaller spray droplets (pressure is the most important factor governing size of droplets).
2. Increased carry of droplets (if pressures do not decrease size of droplets).
3. Increased included angle of spray cone.

Eddy-chamber depth increases cause:

1. Increased carry.
2. Increased output.
3. Decreased atomization.
4. Decreased included angle of spray cone.

Vortex-opening size increases cause:

1. Increased carry.
2. Increased output.
3. Decreased atomization.
4. Decreased included angle of spray cone.

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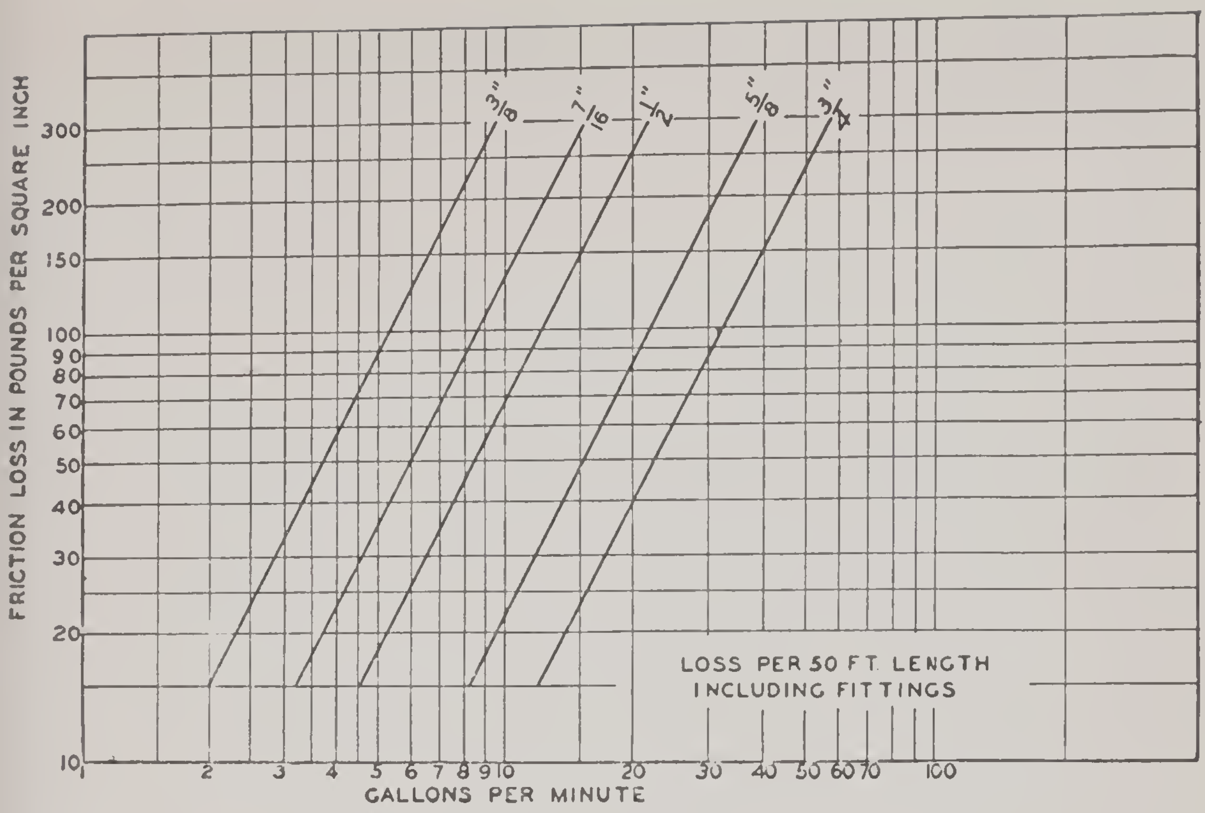
[1] Davies, Cornelius, and G. R. B. Smyth-Homewood. Investigations on machinery used in spraying. Jour. Southeast Agricultural College (Wye, Kent, England), No. 34: 39–52. 1934.



John Bean Mfg. Co., Lansing, Mich.

Figure 210. Friction losses which occur in different sizes of spray hose at various rates of flow.

If the thickness of the disk is increased, the included angle of the spray cone is decreased.

Pressure losses in hose and rod. Pressure loss from pump to nozzle outlet is due to friction of the liquid against the inside walls of the hose or rod. The amount of this pressure loss varies with (1) the length of hose or rod, (2) roughness of the inside walls of the hose, couplings, and rod, and (3) the square of the velocity of flowing liquid. Figure 210 gives the average pressure losses for various sizes of hose carrying different volumes of solution. Tables 29, 30, and 31 give approximate rate of spray discharge of short

TABLE 29

Average Rates of Discharge of a Short Gun Adjusted for Long-Range Spraying[1]

(Adapted from French)

Pressure at Gun in Pounds per Square Inch	Gallons per Minute Discharge Using Disks with the Given Sizes of Orifice					
	3/64 inch	4/64 inch	5/64 inch	6/64 inch	7/64 inch	8/64 inch
200	0.64	1.10	1.70	2.40	3.33	4.10
300	0.79	1.32	2.06	2.90	4.15	5.05
400	0.91	1.55	2.40	3.40	4.75	5.75
500	1.02	1.72	2.69	3.75	5.30	6.40
600	1.13	1.90	2.94	4.12	5.80	7.00

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[1] Short guns adjusted for close-range spraying will deliver approximately 5 to 10 per cent less volume than that shown in the table.

guns, multiple nozzle rods, and bamboo rods. By means of these tables and Figure 210, it is possible to estimate the pressure loss in hose lines equipped with different type nozzles.

TABLE 30

Average Rates of Discharge of a Multiple-Nozzle Gun Having Three or More Nozzles

(Adapted from French)

Pressure at Gun in Pounds per Square Inch	Gallons per Minute per Nozzle with Vortex Plates Having No Central Orifice—for Disk Sizes Given				Gallons per Minute per Nozzle with Vortex Plates Having also Central Orifice of Same Diameter as Disk Sizes Given			
	3/64 inch	4/64 inch	5/64 inch	6/64 inch	3/64 inch	4/64 inch	5/64 inch	6/64 inch
200	0.64	1.25	1.61	2.13	0.67	1.37	1.81	2.41
300	0.79	1.53	1.97	2.60	0.83	1.67	2.23	3.00
400	0.92	1.77	2.27	3.00	0.97	1.93	2.57	3.47
500	1.03	2.00	2.57	3.40	1.08	2.17	2.87	3.87
600	1.13	2.17	2.80	3.70	1.17	2.37	3.17	4.23

TABLE 31

Average Rates of Discharge of a Double-Nozzle 10-Foot Bamboo Rod

(Adapted from French)

Pressure at Base of Rod in Pounds per Square Inch	Gallons per Minute for Nozzles Having Vortex Plates without Central Orifice—for Disk Sizes Given					Gallons per Minute per Nozzle with Vortex Plates Having also Central Orifice of Same Diameter as Disk Sizes Given				
	3/64 inch	4/64 inch	5/64 inch	6/64 inch	7/64 inch	3/64 inch	4/64 inch	5/64 inch	6/64 inch	7/64 inch
200	0.98	1.45	1.80	2.20	2.50	1.42	2.05	3.20	3.72	4.40
300	1.15	1.75	2.15	2.64	2.92	1.75	2.45	3.90	4.60	5.40
400	1.28	2.00	2.42	3.00	3.30	2.00	2.80	4.50	5.30	6.10
500	1.40	2.20	2.70	3.32	3.70	2.20	3.10	5.00	5.90	6.80
600	1.50	2.40	2.90	3.60	3.95	2.40	3.40	5.50	6.40	7.45

Due to construction, some guns may create more friction and "kick" while operating than others. The gun that is most desirable is one which is easy to manipulate and less tiring, does a good job, and has but little kick.

Agitators. Some kind of agitation is needed in all spray tanks in order to provide a more or less uniform concentration of spray solution from the time the tank is full until empty. Agitation for hand sprayers and small power sprayers may be obtained by: (1) swishing of the solution as the operator moves, (2) small by-pass spirt of solution from pump chamber back into supply tank (Figure 205), or (3) simple paddles connected to the pump handle which swish the solution as the pump handle operates (Figure 213).

Agitation is usually provided in power-sprayer tanks by two or more paddles mounted on a lengthwise shaft in the tank, as shown in Figure 206.

The paddles may be of the propeller or flat type. To obtain the same degree of mixing, propeller-type paddles require a greater speed of rotation than square-end flat paddles. However, for certain spray mixtures, the square-end agitators tend to whip an excess of air into the liquid when the tank is almost empty; this causes the pump to operate less efficiently toward the end of the tank supply.

The agitator shaft may be driven either by chain and sprocket, V-belt, or by gears on the spray pump. The agitator shafts are usually mounted so that the paddles sweep within one-half inch of the bottom of the tank. Some spray solutions require greater agitation than others. For example, oil sprays and especially tank-mix oil sprays require considerable agitation. On the other hand, some spray mixtures in which the suspended materials tend to separate, such as lead arsenate, oil and soap, will require a reduced amount of agitation. It is important that obstructions, such as pipes, braces, and filler screens be reduced to a minimum because they tend to produce quiet spots and lower the efficiency of agitation. Some of the recent large power sprayers are providing agitation by jets of spray solution which are pumped under pressure out of a pipe located near the bottom of the supply tank.

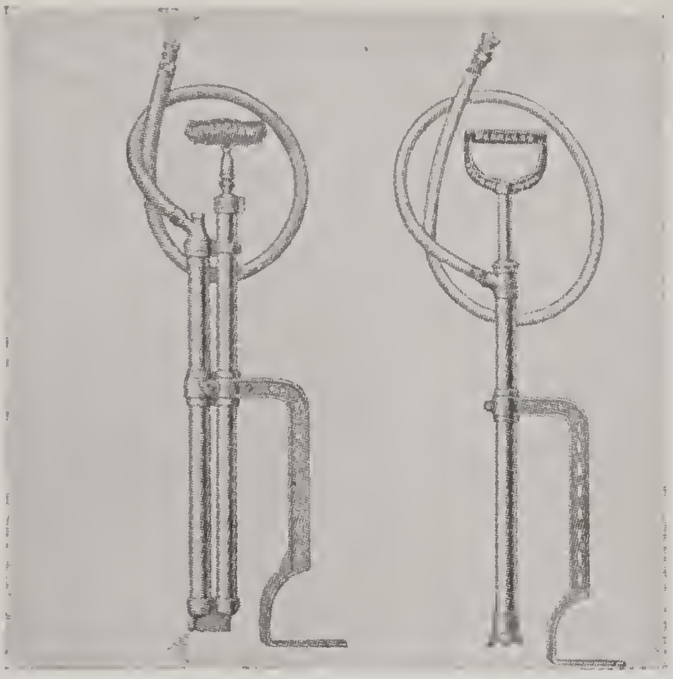
For the same amount of agitation, the circular-bottom type of solution tanks require more agitator-shaft speed and horsepower (80 to 50 per cent, respectively) than the semiflat bottom tanks.

SMALL HAND AND POWER SPRAYERS

These sprayers for fruits may be grouped under the following headings: knapsack, bucket, wheelbarrow, and barrel. The knapsack sprayer has been discussed previously under "Types of Pumps."

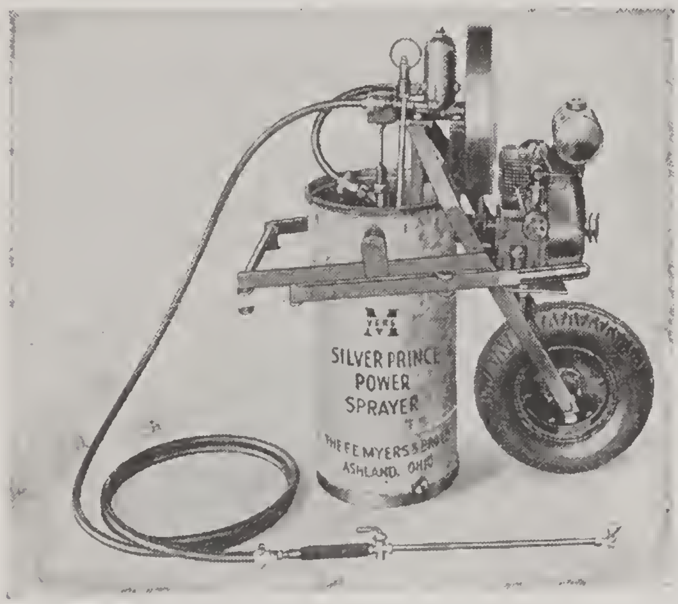
The *bucket pump,* as shown in Figure 211, is satisfactory for a few home garden plants. With a long bamboo rod, it can be used for spraying one or two tall fruit trees. The pump can be clamped to a three-gallon bucket and held steady on the ground by using the foot pedal. The pump plunger is operated with one hand while the spray nozzle is manipulated with the other. There are single and double-acting bucket pumps. The double-acting type is somewhat more expensive, but better. It discharges spray solution on both the up and down stroke. Most bucket pumps have an air chamber for equalizing solution pressure; it may be cylinder-like, or ball-like, or a combination cylinder and ball. Agitation of the solution is usually accomplished by a small jet of liquid forced out at the bottom of the pump. The bucket pump is economical, gives rather even pressure, can be easily cleaned, and the bucket itself is replaceable when corroded. It has small capacity and necessitates continuous pumping.

The *wheelbarrow sprayer* consists of a spray tank of 5- to 18-gallon capacity, mounted as shown in Figure 212. The pump may be operated by hand or by a gasoline or electric motor. The advantages are (1) the operator carries only a part of the load while moving the sprayer, (2) the



F. E. Myers and Bros. Co., Ashland, Ohio

Figure 211. Hand-operated bucket sprayers fit buckets up to a three-gallon capacity and are best adapted to home-garden spraying. The left model pumps on both the up-and-down stroke and has special air-cushion cylinder, giving an even flow of spray.



F. E. Myers and Bros. Co., Ashland, Ohio

Figure 212. Wheel-barrow type power sprayer, driven either by an electric or gasoline motor, is convenient for spraying plants and a few trees in the home garden. Bamboo extension rod is useful for reaching taller plants. Plenty of hose line is recommended. The pump operates at 225 pounds pressure, and the tank holds 12½ gallons.

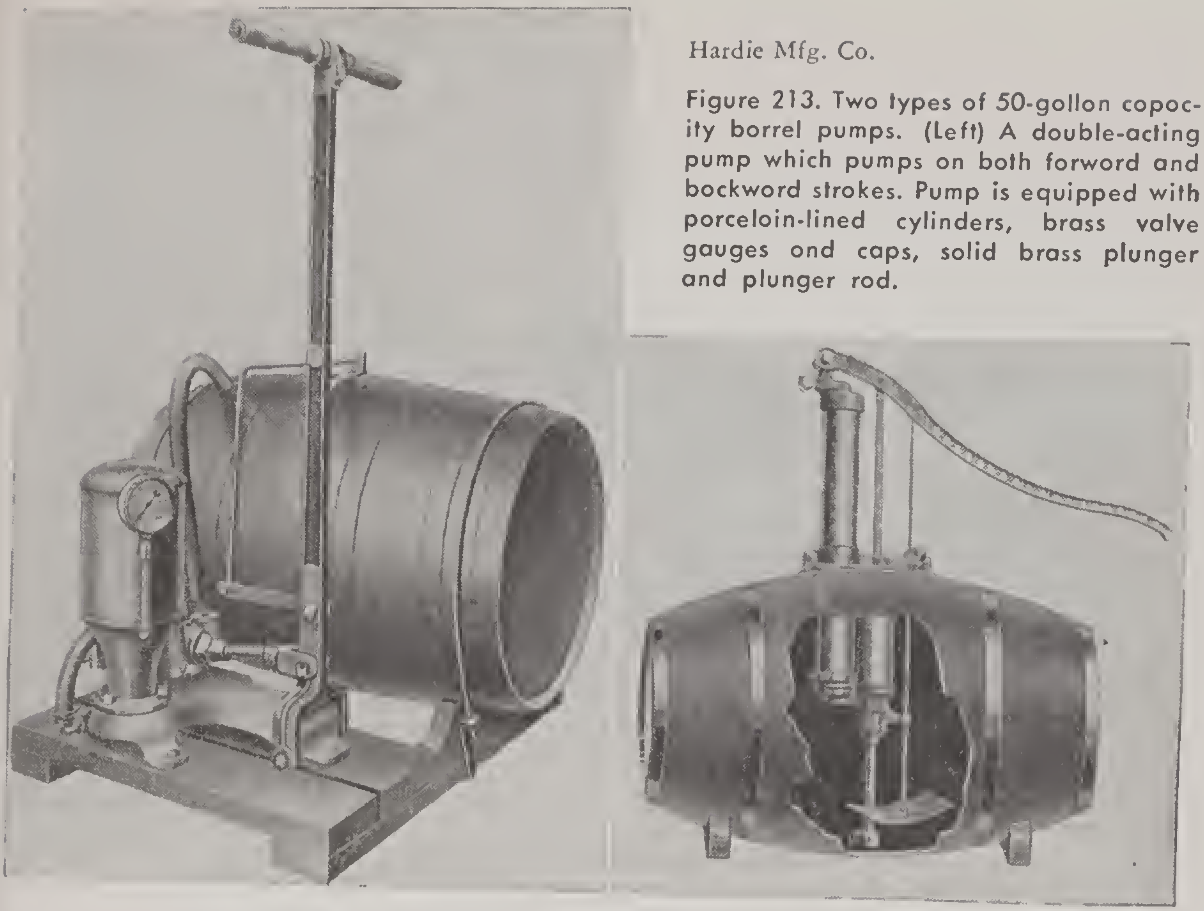
tank is readily cleaned, (3) has efficient agitation, (4) pressure is fair and even, and (5) it is useful for spraying one or two fruit trees and a few grapevines and bush fruits. The sprayer has the disadvantages of accommodating only one or two acres of low plants and requiring two men to spray if hand operated. Motor-equipped wheelbarrow sprayers are much less tiresome to operate.

The pump is often similar to the pump on a bucket sprayer or a barrel sprayer. When equipped with an air chamber, a continuous even supply of spray solution is provided. A steel or rubber-tired wheel is available.

The *barrel sprayer* may be hand (Figure 213) or motor driven and can be used to cover two or three acres of fruit trees and a somewhat larger area of low-growing plants. There are several models of barrel sprayers. They usually contain 50 gallons and operate at a pressure of 100 to 400 pounds in accordance with the pump size and power. Barrel sprayers have more capacity and a longer spraying range (±20 feet) than wheelbarrow sprayers.

LARGE PORTABLE POWER SPRAYERS

Rigs with auxiliary engines. This type of power sprayer is a complete unit with tank, pump and auxiliary engine, all mounted on a chassis and usually pulled by a tractor. With this type of equipment, the capacity and pressure of the pump are independent of ground condi-



Hardie Mfg. Co.

Figure 213. Two types of 50-gallon capacity barrel pumps. (Left) A double-acting pump which pumps on both forward and backward strokes. Pump is equipped with porcelain-lined cylinders, brass valve gauges and caps, solid brass plunger and plunger rod. (Right) Air cushion is provided in left cylinder, while right cylinder contains the plunger. Suction pipe is provided with screen at base. Note type of agitator. Operation pressure is about 125 pounds. Vermorel nozzles or disk nozzles are popular with eight-foot extension rod.

tions or of the type of power used for transportation. It is not uncommon to see the tank, pump, and auxiliary engine mounted on a motor truck. This arrangement is preferred by operators of custom sprayers who may travel a considerable distance from one orchard to another making spraying their business.

Auxiliary engines of power outfits should be capable of operating the spray pump at maximum output without being loaded to more than 75 per cent of their rated horsepower. The engine should be provided with a governor to regulate its speed according to the pump load. Water-cooled engines are employed on all sprayers except some of the smaller portable outfits. Some engines are cooled not by radiators and fans, but by pipe coils installed in the spray tank. This method is satisfactory provided the sprayer is not operated for long periods with one tank of spray material, in which case the spray solution may be injured by the heat absorbed from the coils. There is also the additional disadvantage of the pipe coils reducing the effectiveness of agitation in the spray tank. The chief advantage of this cooling system is the fact that the pump and engine can be completely enclosed under a hood which protects them from dust and spray materials.

Power take-off sprayers. Inasmuch as the majority of sprayers are pulled by tractors, the power from the tractor also can be used for running the spray pump, as shown in Figure 206. The chief advantage of this arrangement is the lower initial cost of the spraying equipment. The main disadvantage is that power take-off outfits may lack the flexibility of an auxiliary engine-driven sprayer. Some manufacturers have improved the power take-off arrangement, however, by providing the sprayer with a transmission having two gear ratios so that with any given tractor speed, a choice of two speeds is available for the pump operation. This gives added flexibility in the choice of ground speeds for spraying on the move.

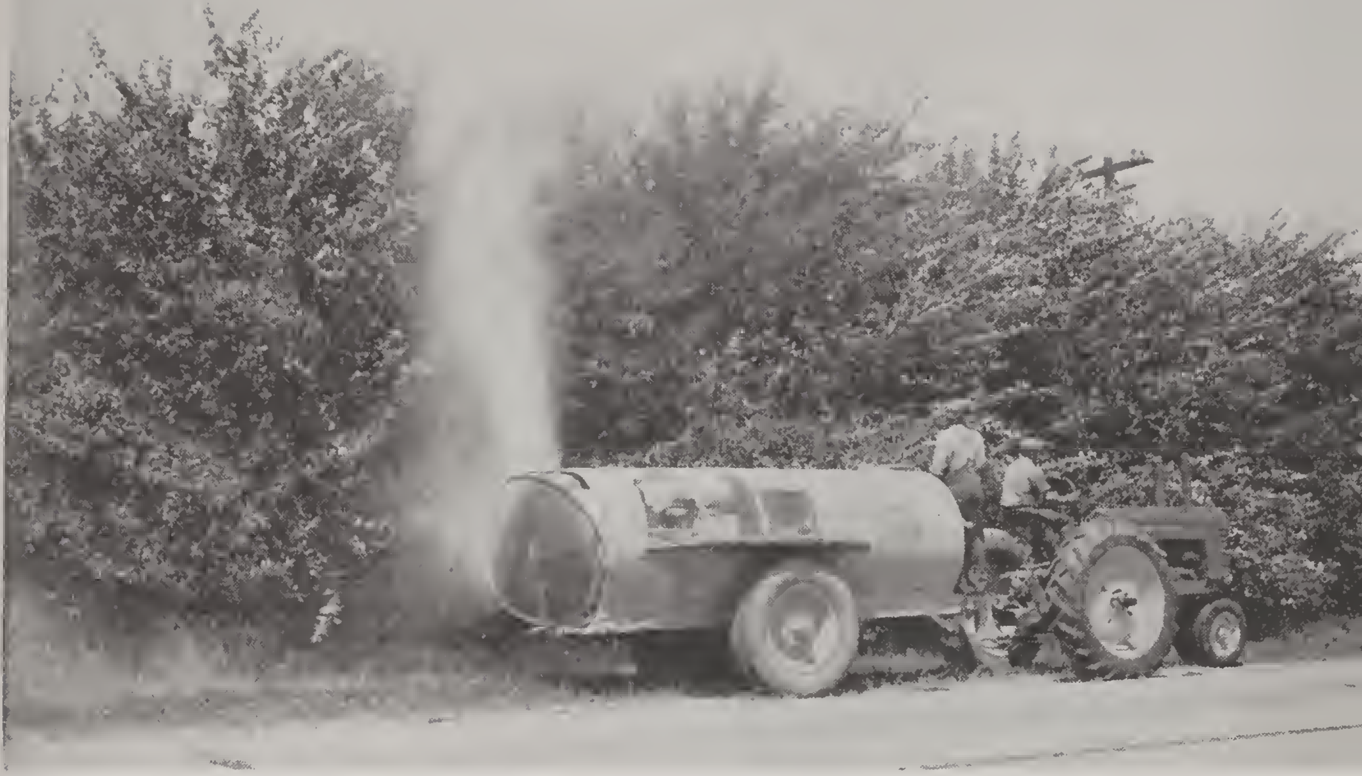
The tractor must have ample reserve power for spraying while moving. With most tractors, the master clutch controls the power take-off shaft and, therefore, it is necessary to disengage the clutch, shift to neutral, and re-engage the master clutch in order to operate the sprayer at each stop. Success with power take-off sprayers depends upon correct selection and operation of the tractor power units, and upon the uniformity and size of trees. Field representatives of spray machine companies are able to furnish information on correct matching of tractor with power take-off equipment.

An added disadvantage to power take-off spraying is the fact that there is severe strain and occasional breakage of the universal joints between the tractor and sprayer on short turns in the orchard. Recent research, however, has made some advancement toward correcting this difficulty.

Traction-driven sprayers. Power for operating the spray pumps of these sprayers is supplied by the support wheels and dependent upon traction between the ground and the wheels. Traction sprayers are limited to row-crop spraying which requires relatively little volume or pressure. These sprayers have been largely replaced by power take-off outfits or sprayers provided with auxiliary engines which give more uniform pressure and permit more latitude in choice of ground speed.

Speed or air-blast sprayers. This type of spray machine (Figure 214) is gaining favor rapidly and may revolutionize orchard spraying. The principle is based on a low-pressure centrifugal pump which delivers the spray material to a battery of nozzles in fixed position. A powerful motor-driven fan discharges a strong air blast (150,000 cu.ft. per minute) back of the nozzles which carries the spray as an enveloping fog drive over and through the trees. It is designed for rapid coverage and saving of labor on large acreages, as one operator can drive the tractor and operate the sprayer. The rigs are usually equipped with a 500-gallon tank and serviced by a tank truck (Figure 215) for rapid refilling which takes about three minutes. These rigs have been reported to spray out from 1500 to 2000 gallons per hour, covering from three to five acres of bearing apple orchard. According to some reports, about 70 acres of 20- to 25-year-old apple trees can be covered in a day.

The Speed Sprayer has shown outstanding performance with peaches. The double head which throws spray from left to right, as shown in Figure 215, is preferred for low-growing trees. Twice the acreage of low trees can be covered in a given time when using the double head, as compared with the single head on mature apple trees.



H. G. Ingerson, John Bean Mfg. Co., Lansing, Mich.

Figure 214. A Speed Sprayer in operation, using a single-head unit for one-way spraying only. Note fine fog forced by heavy draft onto and through the tree.

Accurate control of the air stream is provided through a system of fins or deflectors, located beyond the air tunnel and behind the nozzles. These fins can be easily and quickly adjusted to direct the air stream higher or lower, according to the shape and the height of the tree and the wind condition. The amount of spray material being discharged can be regulated, inasmuch as it is piped through the nozzles in four separate "banks," each bank having an individual quick-acting gate valve. A master control gate valve is provided for instantly feeding or cutting off the material to all nozzles. Provision is also made for adjusting the number of nozzles to avoid waste of material and excessive drenching of foliage and fruit when traveling at low speeds. The speed usually ranges between two to four miles per hour.

It is claimed that effective spraying can be done by this machine against more wind than is possible with a spray gun. This is because the Speed Sprayer can discharge sufficient air to displace the air in the tree and to replace it with air carrying the spray material. For example, the space occupied by an apple tree with a 35-foot limb spread and 20 feet high is 24,500 cubic feet. If the Speed Sprayer is moving past the tree at a rate of two miles per hour, it passes a 35-foot tree in about 12 seconds, in which time 30,000 cubic feet of air are discharged.

Experiences in the East have shown that Speed Sprayers are no more, or, less wasteful of spray material than the conventional portable sprayers in orchards uniformly planted and having trees of uniform size. However, the

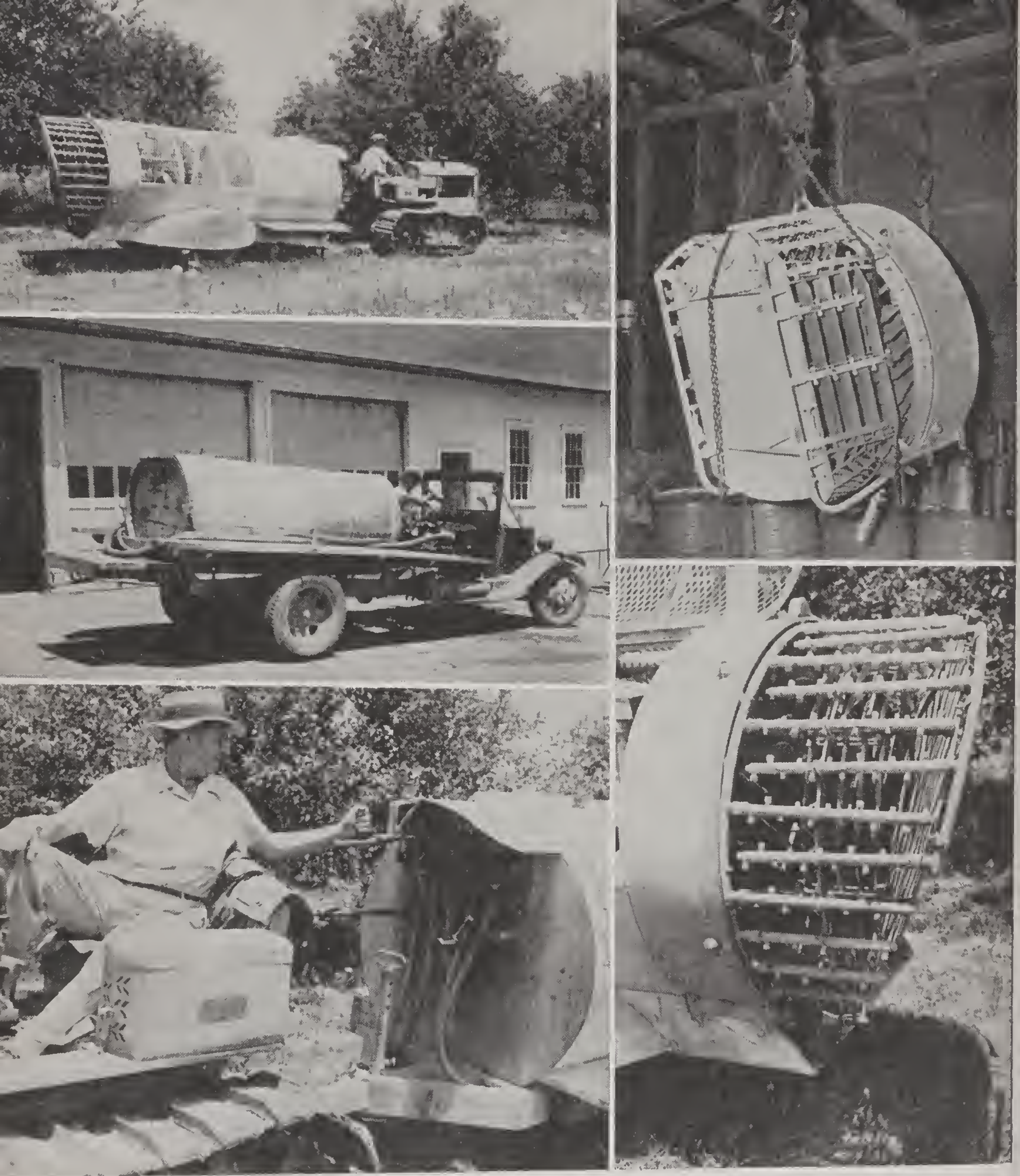
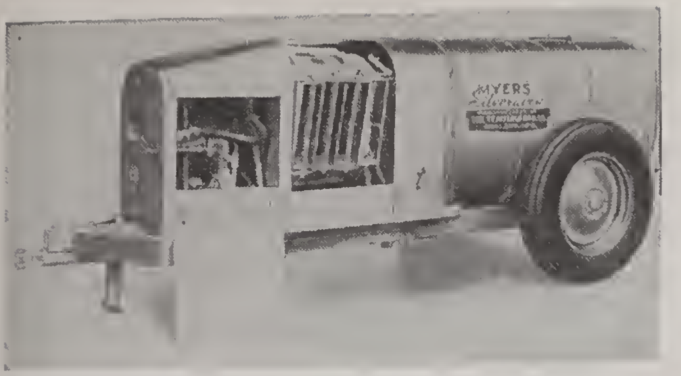


Figure 215. Chief advantage of Speed Sprayer is tremendous capacity with reduced labor. (Top left) A Speed Sprayer pulled with 20 h.p. crawler tractor; (Middle left) 500-gallon wooden water tank mounted on an old truck, the water pump behind the driver transfers a spray solution to Speed Sprayer by power take-off from truck motor; (Bottom left) one man operates tractor and regulates amount and pattern of spraying by levers; (Top right) double-head spray unit used for peaches, mounted on hoist, and ready for attachment to sprayer—mounting time is about 30 minutes; (Bottom right) single-head spray unit is used for covering taller apple trees. Note fins for adjusting flow of mist and numerous small spray nozzles. Fan develops tremendous air current which picks up spray mist and carries it into and through the tree.

Double-tunnel Speed Sprayers with one tunnel on top of the other, spraying one direction only, are gaining in popularity in apple orchards. This model gives better spray coverage in the tips of apple trees and fruit trees of greater height than the peach. See Figure 217 for economical labor-saving spray mast, many modifications of which are on the market.



F. E. Myers and Bros. Co., Ashland, Ohio

Figure 216. An air-blast ("Air-Flo") type orchard power sprayer developed during the war to save labor and give rapid spray coverage. The oscillating nozzle head can be operated up and down by tractor driver or off the engine, thus saving labor. A strong air blast carries mist into tree.

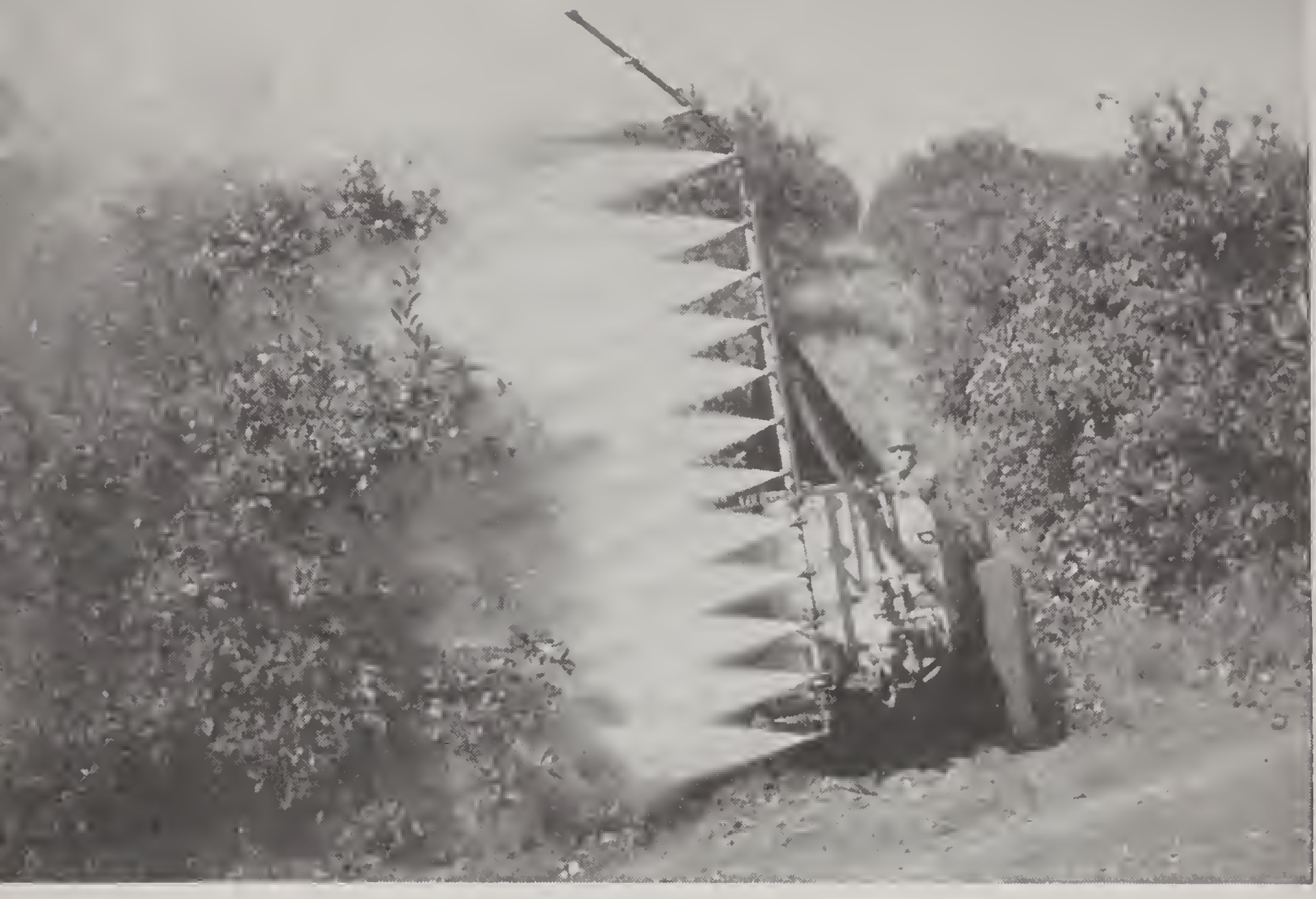
sprayman must be alert in regulating spray output and direction according to tree size and shape. Sufficient time should be given in passing a tree for the fog to penetrate throughout the tree. Trees must be properly opened by pruning to derive the greatest benefits from this type of spraying.

Based on spraying capacity, a single unit should be able to service from 100 to 125 acres of average bearing apple trees and about double this acreage of peaches and cherries. Some growers who have only 50 to 75 acres of orchard, however, are using Speed Sprayers because they reduce the spray job to a minor operation and, thus, give more free time for attention to other tasks on a diversified farm. These growers apparently charge the extra initial expense of the Speed Sprayer to over-all operations, rather than the orchard alone.

Two disadvantages to the Speed and air-blast sprayers are (1) in the foliage sprays the top-centers of tall trees frequently are not thoroughly sprayed even though the spray mist may be blown high above the top, and (2) in the dormant or delayed dormant sprays the twigs and branches are not wet on all sides because each side (two sides) of the tree is sprayed from only one fixed position as the machine passes. This may result in unsatisfactory control of rosy apple aphis, mites, and of scale insects.

Another type of air-blast sprayer is shown in Figure 216 which is different in many respects from the Speed Sprayer and other portable power sprayers. The features are (1) a low-pressure centrifugal pump with a high-volume capacity; (2) electrically controlled "shields" which direct air currents horizontally; (3) vertical movement of bank of spray nozzles; (4) no mechanical agitation; (5) small four-cylinder engine; (6) small centrifugal pump in place of the massive high-pressure pump; (7) no compression chamber or valves; (8) and the elimination of pump crank-shafts, bearings, pistons, and other similar parts that require frequent replacement in high-pressure spray equipment.

Spray tanks. A tank should be selected for portable rigs with as large a capacity as can be pulled to advantage in order to save time in refilling. Either wood or steel tanks are available in standard sizes up to 600 gallons, although much larger tanks are available. Steel tanks are rapidly gaining popularity because they last longer, require less maintenance and permit



Hardie Mfg. Co.

Figure 217. A set of spray nozzles specially mounted on a conventional high-pressure power sprayer saves considerable man labor. The nozzles can be adjusted and operated by one man while another drives the tractor, or it is possible for the tractor driver to do both jobs.

rigid attachment to the frame, which in turn provides greater strength and compactness of the outfit.

Transport trucks and wheel equipment. The power take-off rigs are usually mounted on a two-wheel trailer-type chassis (Figure 206). With this arrangement, the tractor wheels assume a part of the load of the sprayer, and this additional weight increases traction of the tractor wheels. Double wheels, tandem wheels, or crawler-type tracks are often used for the larger power take-off units. The chief advantages are that they distribute the load better on the soil surface and facilitate moving of the equipment over ridges and rough ground. The crawler tracks are best used for the large sprayer units when ground conditions are soft or muddy.

As stated previously, motor trucks are commonly used to carry sprayers where the soil terrain permits. Commercial sprayer operators use this system because sprayers can be transported from one orchard to another more rapidly. Also, if water-supply trucks are not used in the orchard, motor-truck sprayers can save considerable time in returning to the water supply tank for refilling.

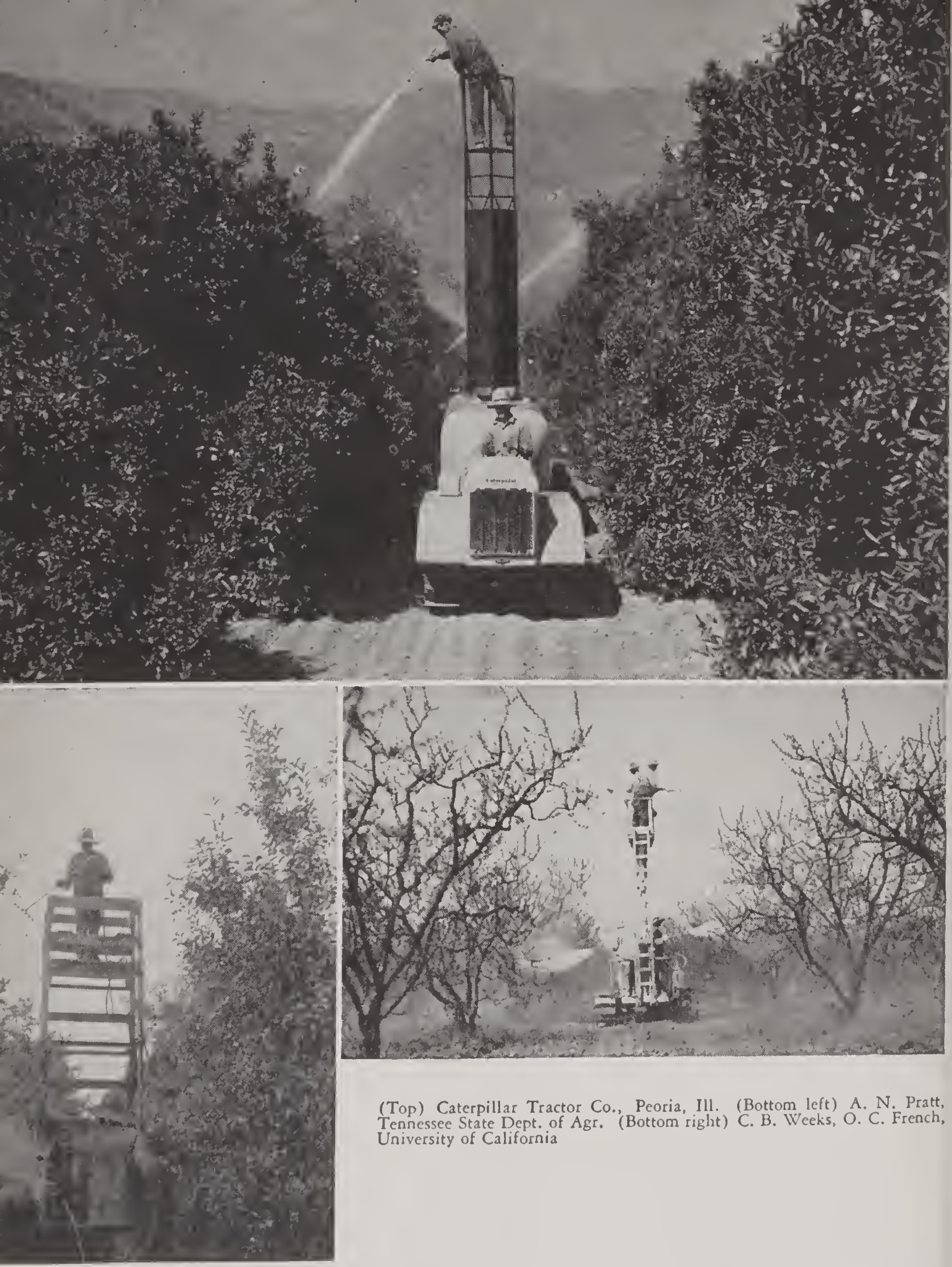
Pneumatic rubber tires are commonly used for spraying equipment because: (1) They increase the life of the sprayer if much traveling is required on hard-surfaced or gravel roads; (2) Draft is less on loose or sandy soils; (3) On wet soils, the large-diameter tractor-type tires clean themselves and do not ball up with mud as do steel wheels; and (4) The equipment can be pulled at higher speeds either for refilling or transportation operations. The small-diameter truck or bus tires are not satisfactory under muddy orchard conditions because they tend to slide along rather than roll. In case of motor-truck outfits, the oversize balloon tires are a distinct advantage because: (1) They do not break down irrigation furrows; (2) They have better traction; and (3) They cause less packing of the soil.

The chief disadvantage of pneumatic rubber tires is the initial cost and depreciation. Some farmers have avoided the higher initial cost by purchasing used truck or bus tires which are satisfactory if muddy conditions are not a problem. Pneumatic tires installed new should last as long as tractor tires, or about seven years or longer. The extra initial cost of rubber tires may not be justified if the sprayer will be used only a few days each year.

Spraying towers. Spray towers can be used best on level or moderately rolling ground. The so-called "pest nest" is in the top center of the tree where it is difficult to thoroughly spray. Furthermore, the largest portion of the crop and the highest-quality fruit are usually carried through the top one-third of the tree. More effective spraying with less effort and materials can be accomplished in this area of the tree if the head of one sprayman is as high or higher than the treetops. This may necessitate the use of an elevated platform or tower on the spray equipment (Figure 218). Modern spraying is commonly done as the equipment moves through the orchard, with one or two men on a tower and the other man or men standing on the rear platform or walking alongside (Figure 218). The fixed-platform may be supported by a three- or four-legged tower which is bolted to the top of the spray tank. The legs may be hinged so that the tower can be lowered and folded when not in use. The fixed-type tower is limited to orchards which have sufficient clearance for the tower among the trees. In case the trees are closely planted, legs of the tower should have smooth metal shields curved around them in order to protect the rubbing branches and fruit from sharp metal.

Ten to 15 feet is usually sufficient height from the ground for the tower platform, although for some citrus spraying and such tall trees as walnuts, a height of from 15 to 30 feet may be necessary. Telescoping hydraulic towers are in common use in California for spraying high trees. With these units, the operator in the "crow's nest" can control his height by opening or closing a hydraulic valve. Some "crow's nests" have a "catwalk" which permits the spray operator to almost stand over the top center of the tree. The extremely tall "catwalk" towers which can accommodate two men and which are used for spraying walnut trees from a height of 30 feet, are mounted on special trailers with wheel treads considerably wider than used for most sprayers in order to give stability.

A 50-gallon iron drum padded around the top and bolted to the top of the spray tank is commonly used in the East for spraying the relatively low trees, such as peaches and sour cherries. Padded rails used on the tops or



(Top) Caterpillar Tractor Co., Peoria, Ill. (Bottom left) A. N. Pratt, Tennessee State Dept. of Agr. (Bottom right) C. B. Weeks, O. C. French, University of California

Figure 218. Spray towers increase effectiveness of coverage of treetops. (Top) A 15-foot fixed metal-shielded tower enables gun operator to thoroughly spray "pest nest." (Bottom left) Home-made wooden tower about 12 feet from the ground. (Bottom right) Large sprayer mounted on tracks and with a tower permitting good coverage as the rig moves continuously. The tower can be lowered by folding over on top of the sprayer.

sides of spray rigs should be about 40 inches above the platform. Nonskid floors on the platform are necessary and some toe boards are good insurance in case the operator slips.

SPRAY MIXING PLANTS AND REFILLING EQUIPMENT

In some orchards, considerable time is wasted in returning to the water tower for refilling. In fact, half of the day may be utilized in some orchards in the refilling operations. Timeliness of application is a prime factor in effective spraying and, therefore, the time required for refilling should be reduced to an absolute minimum. The usual refilling time is about 20 minutes, but this may be reduced to five or ten minutes by operating a special portable water-supply wagon or truck in conjunction with the spray rig. Refilling time can also be reduced by locating water tanks throughout the orchard. A common recommendation is one tank of sufficient size to accommodate each 20-acre block of the orchard. These tanks which are about 3000-gallon capacity may be supplied by gravity or pressure pumping from a larger master tank, which in turn is filled by pumping from a spring or similar water supply. Discarded railroad oil tanks are often used for these water supply tanks. They are mounted on about eight-foot concrete or brick pillars. Some growers use a one-half inch layer of oil on the water surface in these tanks to prevent corrosion of the walls as the water rises and falls. It is important, however, to never completely drain a supply tank into the sprayer tank in order to avoid oil contamination in the spray solution.

The size of the storage tank needed for an orchard or a block of trees will depend upon the supply of water and upon the amount of water needed for one spray period. If the supply of water is small, a pump of small capacity should be used, and the tank should be large. If the pump must operate 24 hours a day, the tank should hold nearly one day's supply of water. If the supply is so small that the pump cannot deliver enough water in 24 hours, then the storage tank should have a capacity sufficient for two or more days of spraying. The following problems are typical for calculating the size of tank, based upon water supply and water needed.

Example 1. What size tank should be installed to supply 9000 gallons of water for one spray if the water supply furnishes only 1½ gallons of water per minute?

A water supply of 1½ gallons per minute, if pumped for 24 hours, delivers 1½ gallons × 60 minutes × 24 hours, or 2160 gallons per day. For three days the pump will deliver 2160 × 3, or 6480 gallons. Since 9000 gallons are needed for one spray and the pump delivers only 6480 gallons in three days, the storage tank at a minimum should hold the difference, 9000 — 6480, or 2520 gallons. In this case the pump is supplying less than is needed or used and a surplus must be stored. The storage tank should hold twice the amount needed, or approximately 5000 gallons.

Example 2. What size storage tank should be used to supply 9000 gallons of water for one spray if the water supply is three gallons per minute?

Three gallons × 60 minutes × 24 hours = 4320 gallons per day. In this case the pump is supplying in 24 hours a sufficient amount of water for one day's spraying, but one must have a reservoir to hold the water pumped during the night, or as a minimum one half of 4320, or approximately 2000 gallons. A 3000-gallon storage space should be provided.

Example 3. When the water supply is large so that a large-capacity pump can be used, the elevated storage tank may be comparatively small. If a pump is used, the capacity of which is equal to the rate used for spraying, the elevated storage tank need be only twice the size of the sprayer tank and the pump may be run only during the daytime. For example, suppose that 9000 gallons are needed for one spray and that the water supply furnishes five gallons per minute. Five gallons × 60 minutes × 10 hours = 3000 gallons per day. Since this is equal to the amount needed, storage space is actually needed only for one spray tank, or 300 gallons. A 500- or 600-gallon storage tank should be used. Of course, a larger tank may be used but it is not needed except in case of a breakdown of the water pump.

Additional information on water supply for the orchard can be obtained from a Cornell bulletin by Jennings (see references).

As stated previously, the most rapid means of refilling a portable spray tank is to use a portable tender tank which is pulled alongside the sprayer and quickly emptied into the spray tank. Transfer of the water may be done by a low-pressure rapid operating pump which is driven by a special one-cylinder motor or by a power take-off from the truck motor (Figure 215). These portable supply tanks may furnish only water or they may carry previously mixed spray material which is well agitated and ready for transfer. This type of equipment is good economy, especially for large capacity sprayers which are using a crew of four or five men.

STATIONARY SPRAY PLANTS

The stationary spray system consists of a permanently located pumping and mixing unit and a connected piping system in the orchard through which the spray solution is forced. It is important that the pumping unit be located at a central point in the orchard. The pipelines are equipped with hydrants to which the rubber spray-hose lines are attached; a sprayman thus can spray a block of several trees from a single hydrant. Stationary spray systems are indispensable in steep orchards where portable equipment cannot travel.

There are several advantages of the stationary spray system: (1) Spray applications can be made on time, regardless of soil conditions; (2) Spraying is facilitated on steep or moderately steep hillsides; (3) The system eliminates compacting of the soil and subsequent erosion by use of wheeled trucks and tractors; (4)[1] There is relatively less wear and tear on the pumping machinery; (5) It eliminates loss of time in refilling portable tanks; (6)[1] All spraying must be done from the ground which may be conducive to a more thorough job of spray coverage; (7)[1] There are lower operating costs. Disadvantages of the stationary spray system include: (1) higher initial cost of equipment and installation, (2) probable interference of pipelines with other orchard operations, (3) inability to spray at night, (4) difficulty in covering tops of trees (an important disadvantage), (5) stationary systems are economically feasible only in long-lived orchards such as pears and apples which require several sprays per season, (6) hydrants and pipe toward the ends of the laterals may become clogged with spray sediment, necessitating time and trouble in unclogging them, and (7) the greater physical labor involved in dragging a long hose on the ground as compared with spraying from the top of a moving rig. Labor in dragging the hoses can be reduced by employing a high-pressure pump which makes possible the use of smaller three-eighths-inch spray hose, in contrast with the heavier standard one-half-inch size.

Stationary pump and mixing plant. The pumping units are identical for stationary systems and portable sprayers, except that electric motors instead of gasoline engines may be used to drive the pump for stationary equipment. The pump capacity will depend upon the desired rate of spray application, but in general, from 35- to 55-gallon per minute pumps are used for stationary systems. A larger pump will permit the use of from six to twelve guns, operated at 450 to 500 pounds pressure per square inch at the nozzle.

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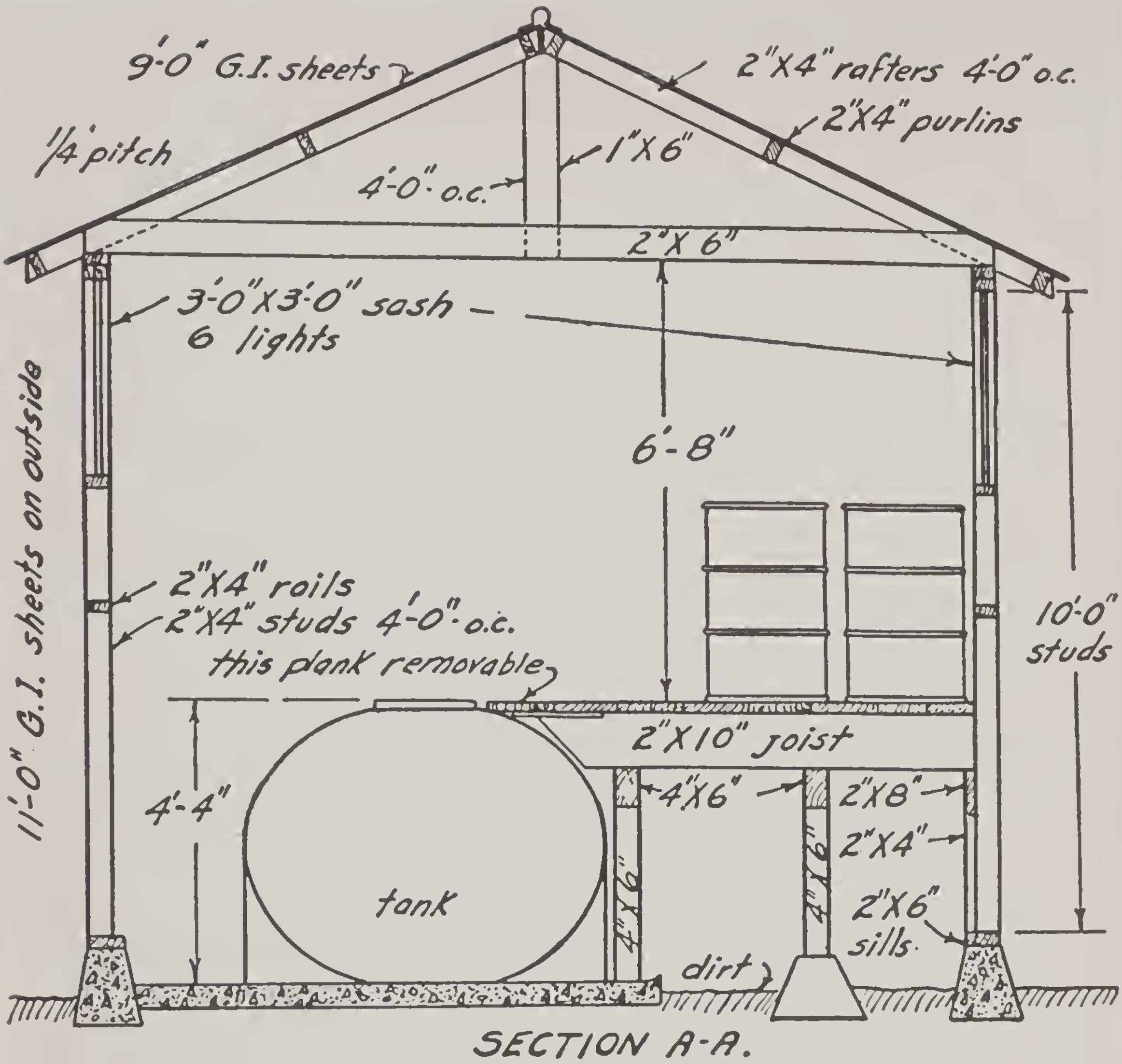
[1] Although these points are frequently listed as advantages of stationary spray plants, they are sometimes doubted by experienced commercial men in light of modern portable spray equipment and methods of application. More research data are needed in which stationary and modern portable equipment are extensively compared.

With No. 4, some people believe there is more wear and tear on the pumping machinery in stationary plants than portable machinery, because the pump is more or less continually operating at a steady and rather full speed regardless of the amount of spray solution being discharged from the nozzles. This puts an extra wear and tear on the pump at intervals when several or all nozzles may not be operating. Some growers and spray machine manufacturers have indicated that, with average labor for running stationary equipment and under average field conditions, probably 15 to 20 per cent of the spraying time is lost in: (1) changing hoses from one hydrant to another, (2) occasional time out for unclogging hydrants at the ends of lines, (3) dragging hoses into better positions for spraying, and (4) because of an environment more conducive to "resting" by the spraymen. With a portable outfit, the spraymen must be continually on the job to keep pace with the steadily moving rig. Also, if for some reason all spraying must stop with a portable rig, the operator normally reduces the engine and pump speed to an idle, or shuts them off entirely, which over many years of service may save considerable pump wear.

In case of No. 6, it is difficult or almost impossible to get as good spray coverage in the top centers of the trees from ground spraying as from spraying off a 12- to 15-foot tower. As stated previously, the top-third of the tree usually carries the most and the highest-quality fruit, and it is imperative that the fruit in this area be covered on all sides.

No. 7 is often questioned by men with considerable practical experience and by representatives of spray machine manufacturers who have made numerous observations. However, these men are unable to present comparable cost data for stationary and portable spraying. It is possible that with recent improvements in portable equipment, the available cost data comparing portable and stationary equipment may have become obsolete.



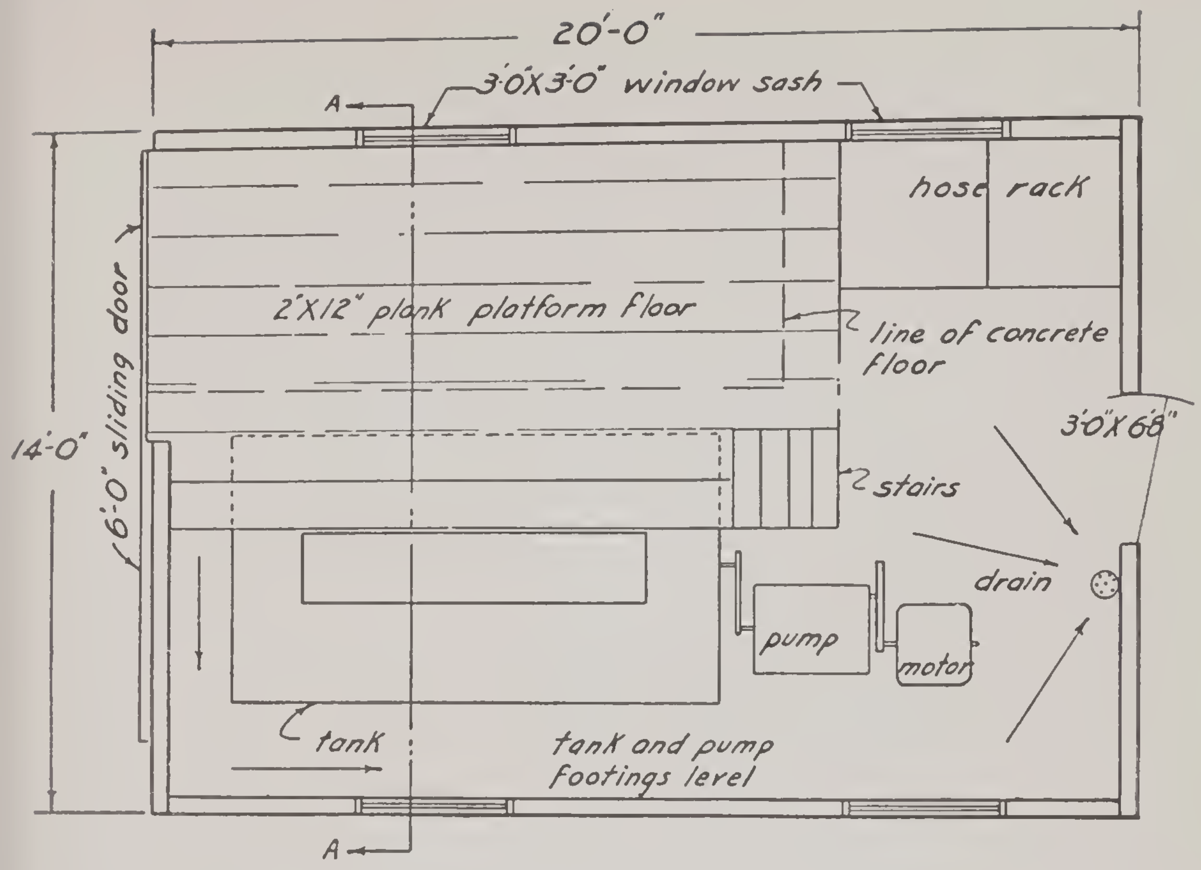
O. C. French, University of California

Figure 219. Cross section of the stationary spray plant house shown in Figure 220.

Pumps to provide this pressure at the nozzle will need to develop 600 to 700 pounds per square inch at the pumping plant.

Figures 219 and 220 show a popular building plan for a stationary unit. The building should be provided with an ample supply of water piped to the spray tanks. The best arrangement for spray tanks is one large tank divided with a partition so that each compartment holds about 600 gallons. The agitator shaft can run through both compartments and operate continuously so that one tank can be filled while the other is being emptied. This affords continuous operation of the spray equipment. The spray plant should be organized so that it can be operated entirely by one man.

Piping design in orchard. No one special plan of piping can be used in all orchards because the plan will vary with: (1) the size and shape of the area to be piped, (2) the topography, (3) the tree spacing, (4) the length of hose lines desired, and (5) the number of spraymen used at one time. It is important to locate the hydrants in the same place in the same pattern of trees in order to eliminate the possibility of spraymen missing trees in odd-pattern designs.



O. C. French, University of California

Figure 220. Floor-plan view of a stationary spray plant house. Cross section of this house taken along line *AA* is shown in Figure 219.

The size of the pipes will depend upon the quantity of liquid pumped through them and upon the length of the runs. The main lines require pipe of one and one-fourth or one and one-half inches in diameter, whereas the lateral pipes should be smaller but not less than three-fourths-inch in diameter. From Table 32, it is possible to compute the loss of pressure from friction in pounds per square inch per 100 feet of pipe at various flows of spray solution in gallons per minute. Figure 210 shows the loss of pressure in hose lines.

Spray solution should move at a velocity of about two feet per second through the pipe lines in order to prevent settling of suspended spray materials. The following figures give the gallons per minute required to give a velocity of two feet per second in iron pipes of different sizes.

Pipe size in inches	*Gallons per minute*
½	2.0
¾	3.3
1	5.4
1¼	10.0
1½	12.7
2	20.0

TABLE 32

Friction Loss in Pipes for Various Rates of Flow[1]

(From French)

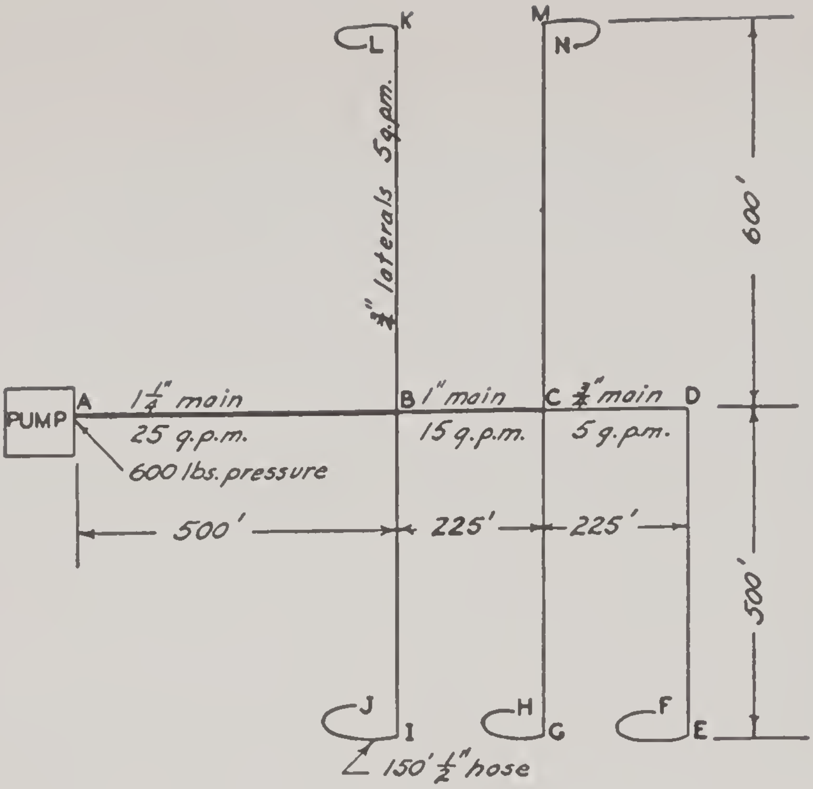
Flow in Gallons per Minute	Loss of Pressure in Pounds per Square Inch per 100 Feet of Pipe of the Given Diameter Sizes					
	½ inch	¾ inch	1 inch	1¼ inch	1½ inch	2 inch
1	0.91	....	....	....	....	....
2	3.22	0.82	....	....	....	....
3	6.85	1.78	0.55	....	....	....
4	11.70	3.04	0.93	0.25	....	....
5	17.78	4.61	1.41	0.36	0.17	....
6	24.72	6.37	1.97	0.52	0.24	....
7	32.95	8.40	2.65	0.69	0.32	....
8	43.50	10.84	3.38	0.88	0.41	....
9	52.50	13.60	4.18	1.08	0.51	....
10	63.75	16.48	5.07	1.32	0.62	0.22
12	....	22.98	7.11	1.87	0.87	0.30
14	....	30.50	9.54	2.47	1.16	0.41
15	....	34.35	10.80	2.82	1.30	0.46
16	....	39.00	12.14	3.17	1.48	0.52
18	....	48.50	15.18	3.95	1.84	0.65
20	....	58.95	18.22	4.83	2.26	0.79
22	....	....	21.60	5.65	2.69	0.90
24	....	....	25.50	6.70	3.17	1.08
25	....	....	27.75	7.20	3.40	1.18
26	....	....	29.50	7.80	3.64	1.27
28	....	....	33.80	8.90	4.21	1.45
30	....	....	38.58	10.18	4.77	1.66
35	....	....	51.60	13.53	6.38	2.21
40	....	....	65.90	17.35	8.15	2.86
45	....	....	....	21.60	10.06	3.56
50	....	....	....	26.01	12.32	4.29

[1] Adapted from: The Hydraulic Society, Standards of the Hydraulic Society. Sixth edition. 96 p. Published by the Hydraulic Society, New York, N. Y. 1931.

The main pipe should be placed, if possible, so that the laterals are of approximately equal length in both directions; this reduces the need for the more expensive large-diameter pipe and tends to equalize pressure losses.

If steep slopes are involved, it requires about 0.43 pound per square inch to raise water one foot. Conversely, about 0.43 pound per square inch is gained for each one-foot drop if the pipeline slopes downward.

In order to estimate the approximate pressure loss in a stationary pipeline system, the following example can be used, based upon the plan shown in Figure 221. "Assuming that five guns, discharging five gallons per minute each, are operating simultaneously, and that the pump pressure is 600



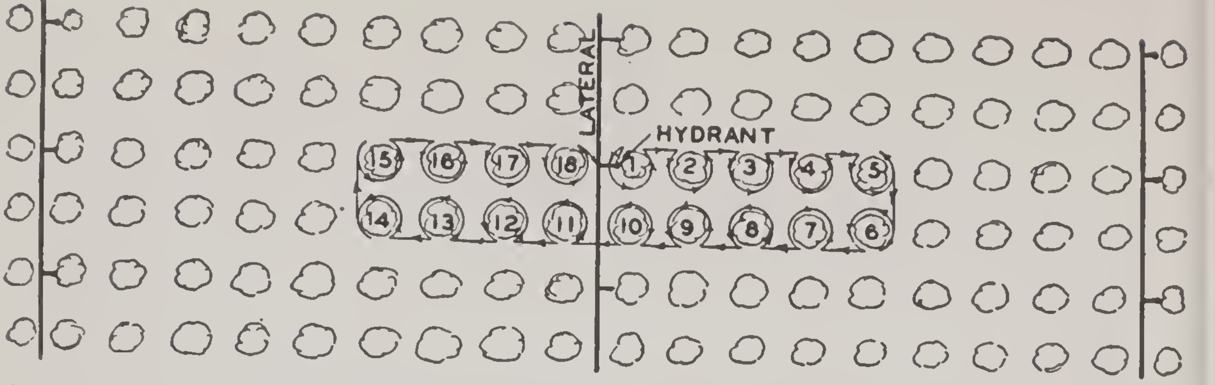
O. C. French, University of California

Figure 221. Schematic plan of dead-end gridiron stationary piping system for estimating pressure loss caused by friction.

pounds per square inch, then by data from Table 30 and Figure 221, determine the pressure loss between the pump and gun F:

	Pounds pressure lost per square inch
A to B = 500 feet of 1¼-inch pipe at 25 g.p.m. = 7.2 × 5	36
B to C = 225 feet of 1-inch pipe at 15 g.p.m = 10.8 × 2.25	24
C to D = 225 feet of ¾-inch pipe at 5 g.p.m. = 4.6 × 2.25	10
D to E = 500 feet of ¾-inch pipe at 5 g.p.m. = 4.6 × 5	23
E to F = 150 feet of ½-inch hose at 5 g.p.m. = 18 × 3	54
	147

The pressure available, therefore, at gun F will be 600 minus 147, which equals 453 pounds per square inch. Likewise, pressure at gun H, J, L, and N



O. C. French, University of California

Figure 222. Diagram of "long-pattern" system of spraying from stationary pipe line. Hydrants are located close to the tree trunks. The sprayman begins at Tree 1 and follows the path indicated by arrows until he has completed the block with Tree 18, then moves to the next hydrant.

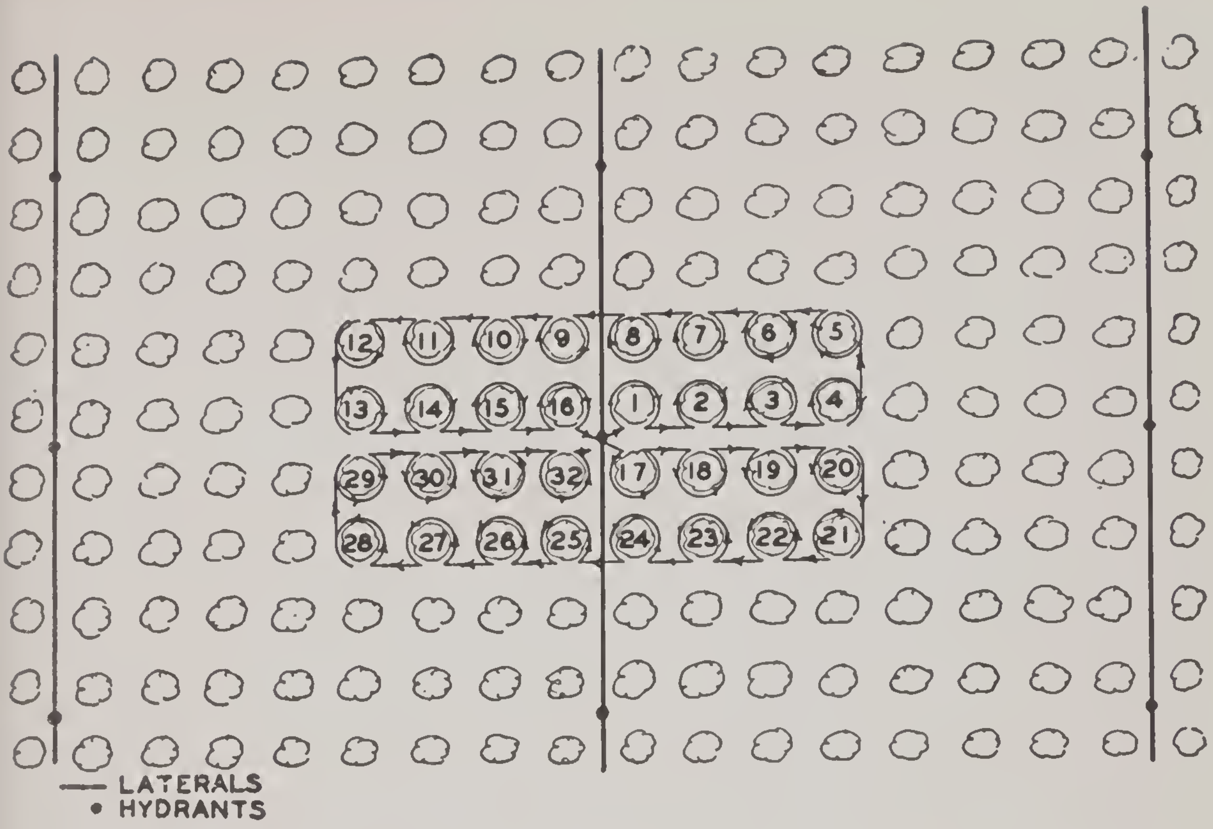
can be computed; they are 463, 487, 482, and 458 pounds per square inch, respectively."

The dead-end gridiron plan for pipe lines is commonly used, as shown in Figure 221. The main line extends centrally through the orchard with laterals at right angles from right and left of the main line. In climates where winter freezing of these pipe lines is not a factor, no provisions are made for draining the lines. However, if freezing is apt to occur, it is usually simple to install drains at the low points.

The more popular "long-pattern" system of stationary spraying consists of risers or hydrants equipped with shut-off valves located near the base of every second tree along the lateral lines. The laterals are spaced about nine trees apart, or, so that not more than 130 feet of hose are required for each block (Figure 222). One man can usually handle up to 130 feet of one-half-inch hose unless there is a high cover crop involved; this is because only about one-half of the hose must be pulled around during the spraying operation. Under some conditions, it may be necessary to hire a young man or boy to help pull the hose.

In some systems, the hydrants with valves may be located on the laterals between the trees and in sunken pits in order to avoid damage by orchard machinery. With this method, no extra ditching and pipe are required for hydrants placed off the line near the tree trunks. As shown in Figure 223, this plan enables the spraymen to cover more trees from a given hydrant than with the "long-pattern" system. Also, fewer hydrants are needed and less time is lost in shifting the hose from one hydrant to another. It may be necessary to uncover the hydrants after each tillage operation, but this usually will not be required more than twice a season.

Pipe line installation. Pipe lines for a stationary spray system can be placed overhead through the tree branches, on the surface of the ground, or buried in the ground. The last system is probably the most desirable, especially where freezing temperatures occur. The pipes are laid about 20 inches deep to permit cultivation over them without damage. If the hydrant valves are located aboveground, they should be placed close to the tree trunks for



O. C. French, University of California

Figure 223. Diagram showing a method of spraying with stationary equipment when hydrants are located directly on the lateral, below ground, and in the center space between four trees.

protection; those placed underground should be deep enough to escape tillage implements. A considerable saving in installation costs can be made by using power equipment to dig trenches for the pipe lines.

Galvanized iron pipe is recommended. Many unions should be employed throughout the system to facilitate future repairs. A good pipe compound should be used for painting all threads. Shutoff valves are recommended for each lateral directly off the main. Hydrant valves with bleeders, commonly designated as stop- and waste-types, save time in disconnecting the spray hose. The piping system should be tested for leaks before covering with soil.

Life of the pipe line depends upon the soil; pipe corrodes in some soils faster than in others. Amount of corrosion likely to be experienced in a given soil can be determined by observing buried pipes in the vicinity. Present spray materials apparently do not seriously injure inside walls of galvanized iron pipe. Many underground stationary spray systems have been in service over twenty years. In California, French reports one orchardist who removed pipe after 27 years of use, and reused it for another stationary system by removing the old ends and rethreading the pipe.

Rate of spraying with stationary systems. In California, studies were made for one season to determine the man-power requirements and the rate of spraying with a stationary system covering 48 acres of medium to small pear trees. Six to seven spraymen applied the spray material by the long-pattern system. Nine sprays were applied during the season, except one application which only covered one-half of the orchard. It required 233

TABLE 33

Comparison of Spraying Costs in the South Block with Portable Rig in 1934 vs. Stationary Equipment in 1935
(Adapted from Burkholder)

1935 Stationary		1934 Portable	
Total gallons on pink, calyx and cover sprays	85,800	Total gallons on pink, calyx, and 7 cover sprays	99,425
Man Hrs......641 at 25 = $160.25		Mans Hrs....1289 at 25 = $322.25	
Man Hrs......209 at 15 = 31.25		Tractor Hrs.. 431 at 50 = 215.50	
Total	$191.60	Gasoline ..215 gal. at 16 = 34.40	
1091 kw-hrs. at 3 cents	32.73	Oil ....2 gal. at 80 = 1.60	
Total labor and power cost	224.33	Total labor and power cost	$533.75
Labor and power cost per 100 gal.	.26	Labor and power cost per 100 gal.	.56
86/190 of depreciation on $2,192.52 at 8⅓% =	82.70	Depreciation on $677.32 at 16⅔%	110.63
86/190 of interest on this investment at 3% =	29.77	Interest on this investment at 3% =	20.32
Total cost per 100 gal. of spray for labor, power, depreciation and interest on investment	.39	Total cost per 100 gal. of spray for labor, power, depreciation, and interest on investment	.70

hours to cover this acreage with the necessary applications during the season. An average of 1.75 acres per hour were covered. It required about 5.3 man-hours per acre, or a total for the season of 2165 man-hours. An average of 40 minutes was required for a man to spray 22 trees in a long-pattern block with an average of 4.5 gallons of spray material per tree. The time necessary for transferring a spray hose from one hydrant to another averaged three minutes which represented a loss of 7 per cent of the total time in moving the hose from one hydrant to another. In California, the total cost of operating stationary plants is usually 15 to 30 per cent less than for portable sprayers.

At Bedford, Indiana, Burkholder showed that the cost of installing a stationary spray plant for 45 acres of orchard could be liquidated in about five seasons by the saving in the application costs which would have been encountered with a portable sprayer. At the end of six years' use at Bedford, the stationary plant showed little evidence of serious wear, whereas the portable rig showed considerable wear. Also, repairs and replacements were less on the stationary plant. Costs of spraying with a stationary plant in Indiana are given in Table 33.

In the East, stationary spray plants are used largely on land too steep for portable outfits. In spite of the advantages listed for stationary equipment, however, probably over 97 per cent of the present spraying is done with portable rigs.

Initial cost of stationary systems. For a moderate size orchard, the cost of the pumping unit of a stationary spray plant should not be greater than for a portable sprayer. However, on large acreage installations, the cost of the pumping plant per acre for stationary systems will usually be less than for portable equipment. The pipe line costs vary, but according to results in California, they run from 25 dollars to 40 dollars per acre in normal times.

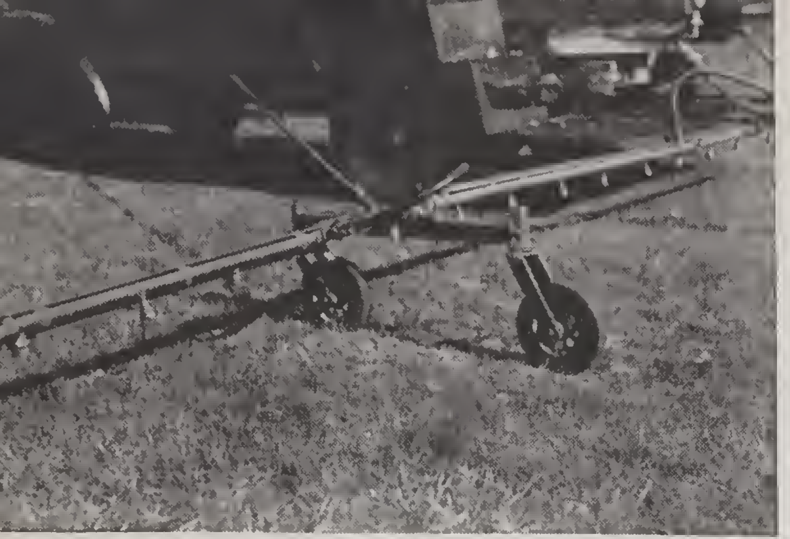
Some growers use stationary pipe installations in steep sections of the orchard and spray the balance of the orchard with a portable sprayer. The portable sprayer is attached to the stationary pipe system to supply the solution for the hillside spraying. If water is readily available, an advantage in pressure can be gained by attaching the portable sprayer at the highest point in the orchard.

Portable pipe-line system. This system of spraying has been used in California orchards to perform spraying operations during periods when the ground is soft and portable sprayers are impractical. Due to the fact the land is adapted to portable spraying, it is assumed that permanent stationary systems are not justified. With this system, a portable sprayer is used as a semistationary plant and is located on a road along the edge of the orchard. Spray material is pumped into a three-quarter-inch pipe line which is taken apart and moved from one block of trees to another. The number of trees covered at one "sitting" varies from 32 to 48. Twenty- to 22-foot lengths of pipe are joined by "quick-detachable" hose couplings at every second joint so that the pipe can be moved easily and quickly. Similar hose couplings are also used on the risers. Special lightweight wrenches to fit the unions are used instead of heavy pipe wrenches. The lengths of hose used vary from 100 to 125 feet. Two extra men beside the sprayman are helpful in moving the pipe and dragging the hose where necessary.

The advantages of the portable-type line system are (1) it is cheaper than the permanent stationary system to install, and (2) the grower who owns a portable sprayer can get his spraying done on schedule when ground conditions may be too wet to pull the sprayer through the orchard. The chief disadvantage is the labor involved for moving the pipe line and the large losses in pressure experienced when long lengths of pipe are required. It is also somewhat more difficult to cover the top centers of large trees.

AIRPLANE SPRAYING

Airplanes equipped with devices for atomizing liquids have been used to a limited extent for several years in California for applying concentrated oil sprays. They are employed in emergencies at seasons when ground conditions are too wet for operation of ground machines. The atomizing devices are located under each wing. A rolling cloud of atomized liquid is dispersed while the plane flies as close to the crop as possible at a speed of 90 to 115 miles per hour. The chief disadvantage of airplane sprayers is that weather conditions must be more nearly perfect than for ground rigs. Consequently, the spray application may be seriously delayed. Furthermore, airplane spraying is limited to commercial operators, since most farmers do not own and



G. W. Keitt, Wisconsin Agr. Exp. Sta.

Figure 224. Boom specially designed for applying ground sprays (e.g. Elgital for supplemental scab control) in orchards. A reflex joint above front wheel permits the end section to swing back when it hits a tree and straighten out when past the obstruction. This equipment might also be used for applying weed sprays.

operate their own plane. The helicopter is undergoing experimentation for spray and dust application and may prove better adapted for this job than airplanes. Spray droplets produced by airplanes should be relatively large, ranging from 150 to 300 microns in diameter. Very small droplets may evaporate before they reach the desired surface.

WEED SPRAYERS

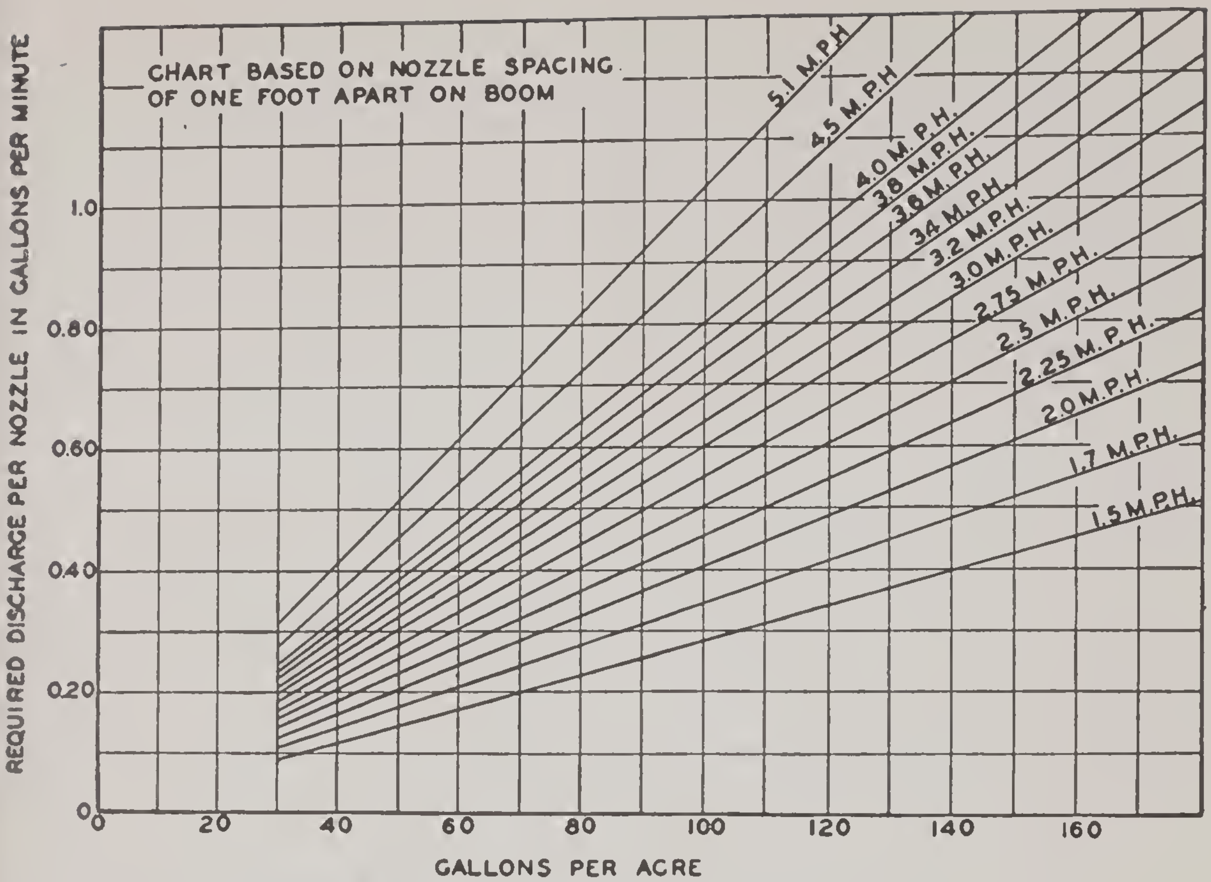
The use of liquid weed killers, or herbicides, is becoming important for controlling weeds in orchards, along roadways and ditches, and in similar areas. A herbicide may kill all plants or weeds with which it comes in contact, or it may be selective and kill only certain weeds, allowing the grasses, for example, to continue growing. An example of a selective herbicide is 2,4-D which is used for eliminating poison ivy, dandelions, and similar obnoxious weeds in the orchard. The most rapid and widespread development in the use of herbicides in orchards has been in California.

The equipment needed for applying liquid herbicides consists of a pump, a supply tank, and a boom having a series of nozzles which emit either a flat fan-type spray or a cone spray, all mounted on some type of chassis for transporting. The use of acid herbicides requires either an acid-resistant type of pump and tank or the ejector-mixing type of sprayer. Acid-resistant nozzles and booms must also be used. For the noncorrosive liquids such as oil, Sinox, and 2,4-D, any type of pump of desired capacity capable of maintaining about 75 pounds pressure per square inch will be satisfactory. Synthetic rubber parts must be installed in sprayers using oil.

Tractor tracks or large diameter pneumatic tractor tires may be necessary for the weed sprayer to prevent bogging down during muddy weather in the spring. A track-layer chassis is more satisfactory for tanks containing more than 400 gallons.

The triplex reciprocating orchard spray pump is most commonly used for weed sprayers. However, a high pressure orchard spray pump is not necessary, inasmuch as only 75 pounds per square inch pressure is needed. Rotary pumps may be satisfactory for nonabrasive materials, but they may wear rapidly if abrasive materials are used. They can be run from the fan belt of automobile trucks or pickup trucks. The tank with boom also may be mounted on the truck.

Special acid-resistant centrifugal pumps are available on the market for



John Bean Mfg. Co., Lansing, Mich.

Figure 225. A chart showing required discharge per nozzle in a boom to give desired quantity per acre at various field speeds. If nozzles are spaced 18 inches apart on the boom, multiply the indicated discharge per nozzle by 1.5; if spacing is 2 feet, multiply by 2.0.

applying dilute sulfuric acid sprays.[1] Cost of these sprayers may be high due to special construction materials. The ordinary cast iron pumps are satisfactory for noncorrosive liquids. A single-stage centrifugal pump is satisfactory, provided its speed is between 2400 and 3600 r.p.m. in order to develop sufficient pressure. About three-fourths to one gallon of spray material will be required per minute per foot of boom used. The length and design of the boom will need to be governed by the crop sprayed.

The better booms have been constructed of one and one-quarter-inch extra heavy pipe. The pipe should be brass for acid sprays and of black iron for noncorrosive sprays. Booms often consist of three sections: one section extending out from each side of the sprayer and one middle section mounted either in the rear or the front of the machine. The sections which extend to the side of the rig must be supported both vertically and horizontally in order to prevent whipping, and they must be arranged so that they can be folded forward while passing through a gate or a narrow pass. The mounting of the boom should be made adjustable for height. Under trees, it may be necessary to spray within a few inches of the ground.

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[1] Manufacturers and distributors of sprayers for weed killing include: Covington's, 317 West Central Ave., Redlands, Calif.; Essick Manufacturing Co., 1950 Santa Fe Ave., Los Angeles, Calif.; Darling Engineering Co., 1343 N. Gardner St., Hollywood, Calif.; California Orchard Heater Co., 413 W. 51st St., Los Angeles 37, Calif.

Nozzles which give a flat fan-shape spray are available on the market. They may be attached to the boom by means of quarter-inch short nipples tapped into the one and one-quarter-inch main pipe. Nozzles that deliver spray at an included angle of 60° should be spaced one foot apart; 80°, 18 inches apart; 90°, two feet apart. The wider spacing of nozzles is more desirable because the cost is then smaller and larger orifices in the disks tend to reduce the danger of clogging. Figure 225 should be of assistance in selection of nozzles for a given boom and of different field speeds for various quantities of spray materials per acre. Figures in this chart are based on a nozzle spacing of one foot. For 18-inch spacing, multiply the discharge per nozzle by 1.5; for two-foot spacing, multiply by 2.0.

It is important to calibrate the boom before taking it into the field. This can be done by placing a trough or small containers under the nozzles and calculating the total discharge per minute. Discharge can be varied somewhat by adjusting the pressure. Nozzle disks of several sizes are available on the market.

For more detailed information on weed control, see the circular by Ball et al. and the book by Robbins et al.

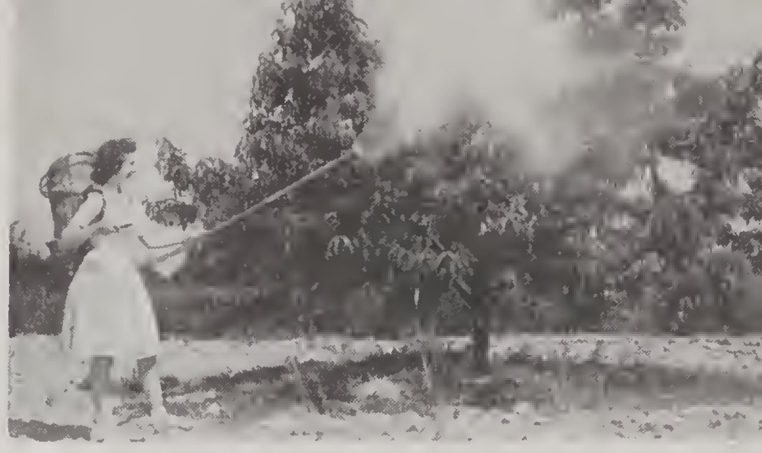
DUSTING MACHINERY AND EQUIPMENT

Hand dusters. Hand dusters are inexpensive and give fair control on a limited amount of foliage. However, they contain only a small quantity of dust, have a limited and uneven dusting range, and some models are difficult to clean. There are several kinds of hand dusters: (1) the shaker, (2) telescope, (3) plunger, and (4) bellows types.

The shaker duster is the simplest hand type. Dusting material is placed in a small cheesecloth bag and shaken above the plants. A gallon tin can with holes punched in the bottom and a wooden handle nailed to one side can be used similarly. These dusters are useful on but a few small plants.

The telescope hand duster is the least expensive sold by manufacturers. It consists of two cardboard cylinders, one telescoped within the other. A one-way simple air valve is located at the bottom of each cylinder. When the cylinders are pulled apart, air is sucked in the lower valve. When they are pushed together, the lower valve closes and the valve on the inner cylinder containing the dust opens so that the air passes through the valve, and through a small perforated pipe within the inner cylinder. As the air passes through this perforated pipe, it sucks the surrounding dust into the pipe and out onto the plants. This duster also is limited in range and capacity.

The plunger hand duster is operated like a hand bicycle pump. The dust may be located in the plunger cylinder or in a glass or metal container attached to the lower end of the cylinder, or it may be located in a bulge at the end of the plunger cylinder. The plunger is pulled back until it passes an air intake port in the cylinder. As the plunger is then forced down, air is pushed out through a side delivery tube, carrying the dust blend with it. The better plunger type hand dusters have a so-called "double action" arrangement, providing a continuous supply of air and dust on both the backward and forward strokes.



Ohio State University Agr. Ext. Serv.

Figure 226. Bellows-type knapsack duster is convenient far dusting larger fruit plants in home gardens. The bellows is pumped with the right hand while dusting pipe is manipulated with left. By standing on a staol ar ladder, it is possible to reach higher in a tree, if necessary.

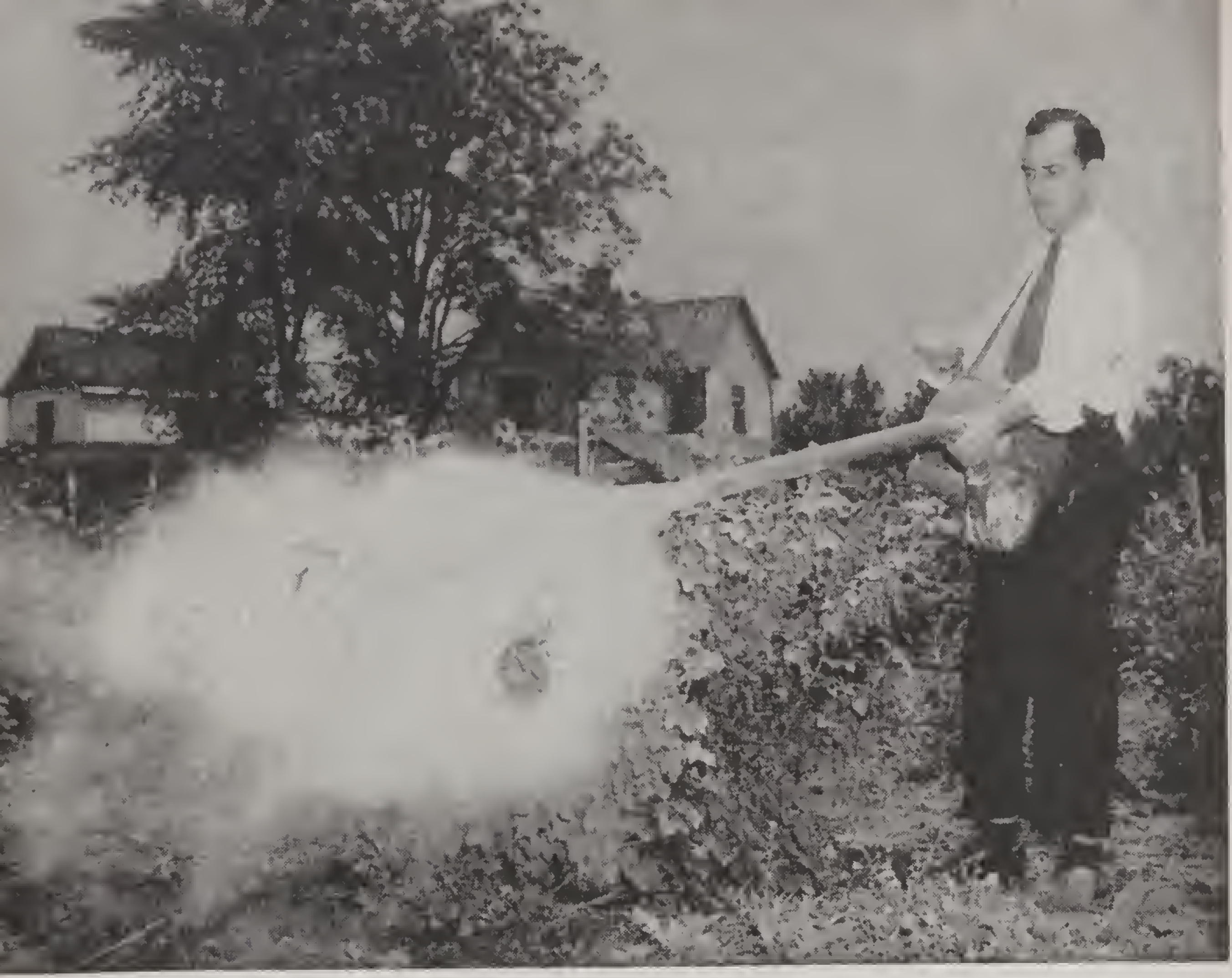
The bellows duster is useful for the same jobs as the bucket-type and small compressed-air sprayers. The dust is carried by gravity through a hole in the base of a small dust container and as the bellows operates by hand, a current of air is driven through the same passage, picking up the dust and carrying it to the plants. As shown in Figure 226, the deluxe knapsack type (described later) is carried on the back of the operator; the dusting pipe is manipulated with one hand while the bellows is operated with the other.

Knapsack dusters. More work can be done with a knapsack duster than with a knapsack sprayer in a given time. As compared with the above types of hand dusters, the knapsack duster has more capacity and wider use, but the initial cost is greater (around $25.00).

The knapsack duster may be operated by a bellows (Figure 226) or by a blower fan (Figure 227). Different types of mouth pieces may be attached to the dusting pipe in order to obtain different angles and patterns of dust distribution. The bellows and fan dusters are about equal in efficiency, but the bellows type may be somewhat easier to operate over a long period. In the fan-type duster, the hand crank drives a blower fan and an agitator. The agitator pushes dust into the near-by fan chamber where it is picked up by the draft and diverted down the flexible delivery tube and onto the plants.

Power dusters. The power duster is simple as compared with the power sprayer. It consists essentially of a gasoline engine, a hopper for the dusting materials and a fan or blower which forces the material through the discharge pipe and onto the trees. The duster may be mounted on a truck, or on skids, or on a two-wheeled trailer in case of a power take-off rig.

The dust is fed into the fan chamber through one or more apertures in the bottom of the hopper (Figure 228). The agitator pulverizes any small lumps in the dust and also helps to provide a continuous and uniform delivery of dust to the fan. The rapidly-revolving fan, which is powered by the auxiliary engine or the power take-off from the tractor, forces the dust out of the discharge pipe in a strong air blast. As shown in Figure 228, the operator manipulates the feed-control lever and discharge pipe to send the material to all parts of the tree. The discharge pipe is about four inches in



Ohio State University Agr. Ext. Serv.

Figure 227. The fan-type of knapsack duster, driven by a crank, gives an even and plentiful flow of dust. It is particularly effective in dusting for currant worm, and it can be used for peach, cherry, and other backyard trees.

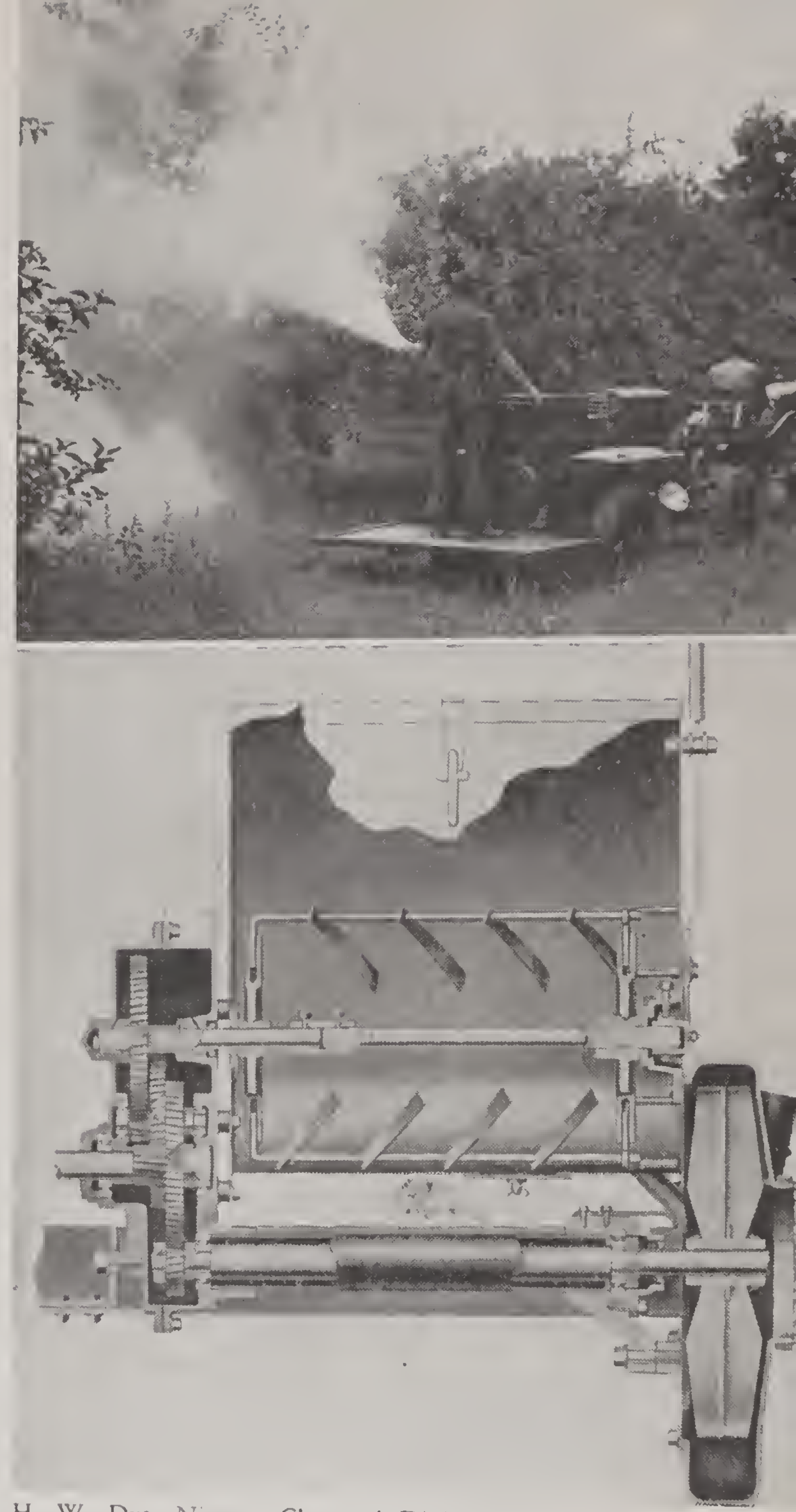
diameter, flexible, and has a provision for attaching extension pipe for dusting tall trees.

Engines of four to eight or more horsepower are used to develop strong air blasts, depending upon the size of the machines. The fans are about 12 inches in diameter and consist of six blades, making 3500 or more revolutions per minute. The hopper should hold at least 100 pounds of dust and be air tight. The opening for filling the hopper with dust should be large.

Airplane duster. Airplane dusting has been practiced for many years on citrus and recently some airplane dusting has been done on deciduous trees. Airplane dusting is best adapted to large rather level acreages of a given crop. The field and borders should be free of interfering power lines, buildings, and similar dangerous obstacles. Airplane dusting is largely performed between daybreak and about eight or nine o'clock in the morning when wind velocity is very low. Due to poor visibility at daybreak, it is well for the pilot to practice flying over the field during daylight hours the previous day in order to "spot" any obstacles. The airplane must travel about 100 m.p.h. within a few feet of the treetops. Special precautions are necessary to spread dust on the plants at the edge of the field.

The dust hopper may contain from 500 to 2000 pounds of the dust blend, and is located low on the fuselage between the engine and the pilot. The agitator in the hopper is rotated by a separate wind-driven propeller. The agitator pushes the dust mixture into a small chamber immediately above the delivery slot. The amount of dust coming through the small sliding valve at the delivery slot can be regulated by the pilot. The so-called "venturi" acts as a metal air guide to catch and concentrate a flow of air past the delivery slot. There are several shapes and sizes of venturis which may be classified in either of two groups: (*a*) The modified-cone type which catches the air current at the large end of the metal cone and increases the air speed past the dust delivery slot, discharging it through the small end of the cone, and (*b*) the miniature airplane wing type. This wing is mounted on the base of the airplane so that air passes between the plane body and the miniature wing, increasing the speed of the air current, picking up the dust, and discharging it in a cloud behind.

The advantages of airplane dusting, where feasible, are (1) large acreages of fruit crops can be covered with dust in three or four hours, (2) no labor and equipment are needed by the orchard owner, eliminating depreciation and cost of upkeep, and (3) the expense is not much greater than ground spraying. Disadvantages are (1) weather conditions may be too hazardous for flying at a time when the dust is needed most on the crop, and (2) a damaged or broken down plane may be in repairs for several days during a critical period. The helicopter is



H. W. Dye, Niagara Chemical Division, Food Machinery Corp., Middleport, N. Y.

Figure 228. (Top) Power duster equipped with self-starter, generator, battery box, and lights for night dusting, pneumatic rubber tires, and a bag rack for additional dust. (Bottom) Cut-away illustration of power duster. Agitator stirs the dust in hopper and feeds it through lower right pipe. A 16-inch, steel-bladed fan, operating at 3600 r.p.m. and generating an air velocity of 185 m.p.h., picks up dust and discharges it through pipe at upper right of fan. Operator regulates rate of dust flow by lever at right.

showing some advantages over the airplane, particularly from the standpoint of safety.

A point of interest in airplane dusting is the fact that the dust is given an electrical charge on leaving the plane. If the charge is the same as that held by the leaf, the dust is repelled; if the charge is different, they attract each other and the dust will stick. As yet, this charge cannot be controlled in a practical way.

CARE OF MACHINERY AND EQUIPMENT

Frequent and thorough lubrication of all working parts of spray machinery is highly important during the operating season. At the end of each day of use, thoroughly rinse the tank, and pump clean water through the system. Open the nozzles until the water is discharged. Special care of the hose will greatly increase length of usefulness. Do not drag the hose on the ground except when actually spraying. When going for a tank refill, either disconnect the hose from the rig or coil it upon hangers at the rear or sides of the machine. Do not permit kinks to form in the hose.

At the end of the spray season, it is highly important to do a thorough job of rinsing the machine with clean water, then drain the pump, the engine, and the tank. In order to prevent rusting of the pump during the winter, pump used lubrication oil through it. Store the hose in a cool dark place. Drain it completely and coil it over an elevated barrel or stretch it out on a bench or shelf. Do not suspend it on nails or similar objects which may cause it to kink and crack.

The spray machine should be gotten out ahead of time in the spring and gone over completely, thoroughly cleaned, and "tuned up" ready for active use. The following suggestions are given by the John Bean Manufacturing Company for adjustment, overhauling, and care of Bean pumps. While these suggestions do not strictly apply to all makes of spray equipment, they may act as a guide for overhauling and care of sprayers in general.

KNOW YOUR PUMP[1]

Loss of pressure. Do not attempt to readjust regulator until you have checked the following:

1. Look for enlarged holes in nozzle disks—they may be worn so large that pump cannot supply enough liquid to maintain pressure.
2. Plunger packing may be leaking—renew packing immediately when leakage develops.
3. Inspect strainer on intake. There must be a free flow of water to pump.
4. Check for air leak or obstruction in intake pipes.
5. Valves may be worn or dirty.
6. Engine may not be running up to correct speed.

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[1] Fasten a copy of these suggestions on the shop wall for reference.

Pressure regulator. Clean out foreign matter which may be lodged at ball above stem. Replace valve seat and ball if worn. Check stem adjustment with stem gauge furnished. Stem should be set for about $\frac{1}{16}$-inch clearance under ball. To adjust stem:

1. Release pressure on pump.
2. Loosen lower nut and lock to upper nut.
3. Turn stem until just touches ball (place finger on ball and you can feel it touch).
4. Turn stem down two complete turns.
5. Release lower nut and turn down tightly to hold stem where set.

Pump plungers. Replace plunger packing immediately when leakage develops. Clean cylinder walls and edges of cup nuts when renewing packing. Oil plungers before inserting.

Pump valves. If clogged with dirt or if balls and seats are worn, pump efficiency will be greatly reduced. Run clear water through pump to wash out valves after each day's work.

Intake strainer. Must be kept clean or pump will knock and not deliver capacity.

Vibration. Caused by loose packing around stem in pressure regulator. Tighten packing nut to stop chattering or vibration; renew packing if necessary.

Drive chain. Keep chain at proper tension. Too tight a chain will waste power and cause rapid wear. Too loose a chain will climb sprockets and cause wear and breakage. Keep sprockets properly aligned to prevent side wear. Use only light oil for chain lubrication.

Air cushion. Run water through pump to wet valves and plungers, then release pressure and pump air cushion. A half minute is long enough to pump air—to run longer may cause an air lock.

Freezing weather. Open discharge and run idle a few moments, which will blow out valves. Remove all drain plugs and leave open. Some pumps must also have the four lower balls raised to release water trapped above them. Until thoroughly familiar with outfit, remove a cap here and there to insure complete drainage.

OVERHAULING THE SPRAYER[1]

General.

1. Thoroughly clean entire machine.
2. Use oil and grease to protect exposed parts subject to rusting.
3. Repaint if needed. The well-cared for machine usually looks well cared for.

Pump.

1. Inspect plunger packing and porcelain cylinder walls. Replace if necessary.

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[1] Fasten a copy of these suggestions on the shop wall for reference.

2. Inspect all valves, clean thoroughly, and replace parts only if absolutely necessary. Inspect valve gaskets.

3. Check condition of gears and gear alignment. Loose bearings will cause rapid wear on gears.

4. Check wrist pins and other points for general wear and looseness.

5. Enclosed pumps may require new oil seals and packing around plunger rods.

6. Put new oil in enclosed pumps and run pump afterward a few minutes to get coating of oil over all inside parts.

Pressure regulator.

1. Inspect condition of diaphragm rubber or hydraulic leather cup.
2. Inspect valve ball and seat directly above stem. This is the most important valve in the pump.
3. Be sure to have good packing around top of stem. Keep this packing tight.
4. Carefully adjust stem in accordance with instruction book.

Drive parts.

1. Gear drive—Adjust gears to mesh properly.
2. Chain drive—Remove chain and clean in kerosene; re-oil thoroughly before replacing. Check alignment of sprockets. Adjust chain tension.
3. V-belt drive—Keep belts clean and tight. They must not slip.
4. Power-take-off universals—Extreme wear may indicate poor hookup or careless operation when turning. Grease the sliding square shaft.

Engine.

1. Check compression and determine if necessary to grind valves and overhaul pistons.
2. Check bearings for looseness.
3. Clean and adjust spark plugs.
4. Clean outside of radiator. A clogged radiator cannot cool the engine.
5. Magneto—Take to nearest official Wico service station if necessary.

Suction to pump.

1. Clean strainer screen.
2. Inspect suction hose. It must not leak air.
3. Check pipe connections.

Tank.

1. Steel tank—If inside is in good condition, do not disturb. If it shows rust pits, clean and coat with heavy oil or light grease.
2. Wood tank—Hoops may require tightening but be careful and loosen as may be necessary when tank swells in usage next spring.
3. Agitator—May require overhauling—Use waterpump grease in agitator bearings.

Truck and frame.

1. Tighten bolts which may have loosened.
2. Repair any breaks or cracks in frame by welding.

3. Inspect wheel bearings and pack with grease.
4. See that hitch is in good condition.

Discharge equipment.

1. Hose should be removed and stored away from heat and light.
2. Spray Guns—Probably need repairing and replacement parts.

In case of a power duster, drain the engine at the end of the season, clean the hopper thoroughly, and coat all corrosive parts with heavy oil or grease.

Accurate scales and measuring cans should be readily available. It is a wise investment to have a good stock of repair parts for the engines, pumps, and rig frames before the season begins. Although some manufacturers attempt to give air-express service on repair parts from the factory, as much as a day or two may be lost in securing these parts during a critical period. Among the extra parts which the grower might well have in reserve are agitator paddles, cylinder-head gaskets, connecting rods, spare belts, extra chain links, disks and vortex plates for nozzles, gaskets for nozzles, hose clamps, connections and washers, extra nozzles, pistons, pump packing, plunger cups, spark plugs, spray hose, extra spray guns and brooms, stove bolts, suction hose, suction strainer for hose, valve balls, seats, springs, and repair tools. If several outfits are working in an orchard, it may be well to have in reserve an extra engine and pump, both in good working condition with all connections. The spray rig parts should be pigeon-holed by classification and those subject to corrosion should be protected by a heavy coating of oil or grease.

APPLICATION OF SPRAYS AND DUSTS

Applying spray. The most important factor in efficient spraying is the sprayman himself. He must start each application on time, finish on time, and use the equipment and methods skillfully so that every tree is thoroughly sprayed inside and out, top to bottom, with finely-broken spray fog applied in such a way as to give safe uniform coverage. There is no substitute for a skillful, alert thorough-working sprayman.

It is relatively easy to do a good spray job on small trees, but as the trees reach 15 feet or higher, the tops and especially the top centers become increasingly difficult to thoroughly cover. In fact, with trees 20 feet or higher, it is hard to find a sprayman giving thorough coverage to the upper third and top centers of the trees. Scabby and wormy fruit at the end of the season often tell a bad story of poor spraying in this section of the trees.

Most spraying failures can be attributed to "skimpy gallonage." After what appears to be a thorough spray application, the top of the tree often carries one-third less spray material than the bottom. The top third, or "pest nest," must receive special attention during the spraying operation. A common practice in the East is to apply a special "top-off" spray between the regular sprays in order to attain good control in the tops. As shown in Figure 203, apples may double their surface area every week or two soon after fruit set and applications made as close as a week apart may be necessary to build up effective spray barriers where codling moth is a problem. Some varieties increase rapidly in size early in the season, such as Delicious, Rome, and Rhode Island Greening, and they need somewhat more frequent coverage than varieties which tend to grow more slowly at this period, such as Grimes Golden and Winesap.

On taller trees, the multiple-cluster fog-drive brooms may not place sufficient spray material in the tops of the trees; this area can often be covered best with a single or double nozzle spray gun. A spray tower on the rig is often needed to get a good job on treetops while spraying from a moving machine. The spray fog must be driven over the tops. The sprayman should carry the upstroke high enough to see the top of the tree below the spray-fog drive. Timely, speedy applications are needed in early season scab sprays to cover the upper surfaces of the expanding leaves and blossoms. It is especially important to cover all sides of the apples for controlling such pests as codling moth, bitter rot, Brook's fruit spot, and blotch. This often necessitates spraying from the ground underneath the branches as a supplement to the usual outside spraying. The spray fog is directed up and out at all angles to cover all surfaces of the fruit.

Large trees with bushy interiors and branches hanging to the ground cannot be covered by any practical method of spraying. It is highly important that the pruning program be co-ordinated with the spray program to lower tops of tall trees, eliminate underhanging branches, and thin out dense areas to permit thorough penetration and application of sprays. This is especially important where large capacity rigs are used, such as the Speed Sprayer, which apply spray while continuously moving. As described under "Pruning of Apples" in Chapter IV, the so-called four-leaf clover system of pruning, where "walk-in" or "pie-shaped" alleyways are cut into large trees, provide ideal entranceways for swirling spray fogs to enter and settle in the center of the trees.

A good method for the grower to check efficiency in spray coverage is to hang two- to three-inch diameter sponge rubber balls by wire hooks in different parts of typical trees. This method can also be used to check on the efficiency of different types of spray equipment.

Fog-drive brooms operating with 400 to 600 pounds pressure have given no mechanical injury where the fruits or foliage were sprayed with the nozzles almost against the fruit or leaf surface. Single-nozzle short guns when adjusted to the wide fog spray are usually safe to within three to five feet of the nozzle. However, when they are wide open and giving a driving spray, they are seldom safe closer than 10 to 15 feet from the nozzle. The sprayman using a single-nozzle gun must be continually alert and have good "spray-fog sense" in order to apply the spray material well and without risk of mechanical injury. The single-nozzle gun has a place with tall trees sprayed from the ground and also for spraying the tops of tall trees from a tower on a portable sprayer. The gun shown in Figure 206 has been used widely for applying the entire spray quota to each tree. The gun can deliver about 25 gallons a minute and is quickly adjustable to short or distant spraying.

Spraying from the tops of portable rigs where practicable is most convenient for the spraymen and permits use of both broom and gun combinations that take the capacity of the larger pumps. This gives the spraymen more gallons per minute to handle than almost any other method, except the speed or air-blast sprayers. Spraying from the rig has marked disadvantages in working against wind, especially with fog-drive guns, and in traveling over soft ground early in the season. Also, it is usually difficult to secure satisfactory penetration of spray into the tree from all angles by spraying only from the rig. Tank spraying has given best results for control of such diseases as apple scab and cherry leaf spot, provided the spraying has been completed on time. It has given less satisfactory results in the control of codling moth, red mite, scale, aphis, flea-weevil, bitter rot, blotch, and Brook's fruit spot.

The combination of tank and ground spraying is often the most effective. Excellent coverage is obtained on mature trees by spraying from the ground, provided guns of sufficient capacity are used for covering the tops of the trees. This method is still widely used for many portable sprayers and, of course, entirely with stationary spray systems.

Although a better job can be done by spraying with the wind, many difficulties may be encountered when growers insist on spraying only with the wind, because often the orchard is not completely sprayed within the necessary time interval for best control of pests. With large-capacity, high-pressure equipment, it is possible to develop a technique of spraying at an angle into the wind and securing adequate coverage without wasting material. It is highly important that applications be completed on time and that methods be employed to secure prompt complete coverage. The equipment must be adequate to cover the orchard in three days or less, especially for apple scab sprays, and on some occasions during critical scab development periods, it may be necessary to cover the orchard within 24 hours for best control.

It should be emphasized that poor spraying is responsible for more failures to control insects and diseases than any other course.

Equipment for night spraying. As a result of high winds and occasional high temperatures, it is often difficult or impossible to apply all the spray during the day. In order to finish the spray job on time, it may be necessary during such periods to spray at night after the wind has died down and conditions are generally more favorable. However, if high humidities should occur during the night and the spray is not drying before morning, severe burning or russeting of the foliage or fruit may occur. It is necessary, therefore, for the operator to check carefully to be sure that the spray is drying at night in a moderate length of time.

Night operations are limited to situations where the operator rides the moving spray tank if there is only one light source. In this case, light is provided by a single headlight bulb attached to the top of a pole which is elevated about the operator's head at or about the center of the spray machine. Electricity can be supplied by an ordinary storage battery which is charged by a special automobile motor generator operated by the sprayer engine or by the tractor drawing the sprayer.

If the individual spraymen wear headlights, one man can spray from the tank or tower and the other from the ground position as in daylight spraying. Individual electric headlights worn on the cap are available. Storage batteries attached to pant belts provide the electricity. Such equipment was originally designed for use by coal miners but is excellent for night spraying operations.[1]

Custom spraying. In some fruit regions, it is not uncommon to find many small orchards or vineyards, each of which hardly justifies good power spraying equipment. As a result, pest control with too-small or poorly maintained pumps is unsatisfactory. A truck-mounted or tractor-pulled sprayer owned by a custom sprayman can service many such orchards or vineyards, and in most cases the results are a definite improvement in market quality of the fruit. Custom spraymen know how to spray properly and are familiar with materials which should be used and when they should be applied. The best results are usually obtained where the operator supplies the materials and charges the owner on a gallon basis for the material applied with a flat rate as the minimum charge. Custom spraymen will find that spray rigs equipped to cover potatoes and vegetables as well as tree fruits are operated more profitably than those equipped to spray only trees. By such an arrangement, the sprayman is able to operate his outfit over a longer season. Charge for this service varies considerably in different communities and from year to year. Cost per tree is less, however, where there are 25 or more trees than where there are only one or two to be sprayed.

Applying dusts. The best time for dusting is when the air is still at the beginning and end of the day. Under these conditions, there is little waste of material and the dust hangs in a cloud or dry fog about the trees for a considerable period (Figure 228). The presence of dew on the leaf surfaces early in the morning and late in the evening, helps the dust to stick better than at periods during midday. Sulfur dusts will adhere to the foliage even though it is dry. Many of the dusts contain adhesive materials.

The dusting machine may move constantly over the ground, going fast for small trees and slower for large trees. A puff of dust is usually sufficient for small trees; the feed lever is opened and closed quickly as the discharge pipe passes the tree. For large trees, the discharge pipe must be moved sufficiently to cover the entire top, including the projecting exterior tips. The trees are dusted by giving an upward and downward sweep of the discharge pipe, using a horizontal stroke across the top and another across the bottom as the machine is leaving the tree. This gives an even coverage with a minimum of material. For very high trees, it may be necessary to use an extension pipe and give the pipe a sudden upward fling at the top of the stroke. The entire operation is a matter of seconds and, therefore, the operator must be agile to do a good job and conserve materials.

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[1] The Mine Safety Appliance Company, Pittsburgh, Pa. is one manufacturer of this equipment. They also have machines for recharging the storage batteries during the day.

Peach trees or other trees of similar size and openness can be dusted from one side only when air conditions are good. However, it is a good idea to make successive applications from alternate sides; for example, spraying the east side during one application and spray the west during the next. Large trees should be dusted from both sides during each application. Thus, about half of the quota is applied to one side and half to the other side.

Careful adjustment of the speed control lever is important in order to get a good coverage but still not waste material. The amount of material applied per tree can be checked by dividing the number of trees covered by the poundage of material placed in the hopper for a given application. The quantity of dust ordinarily required for different fruit plants by age is given in Table 34.

Growers may do considerable dusting at night using lights maintained by a special generator. Air conditions are good at night and the job can be hastened by almost continuous operation of the machine.

Dusting versus spraying. Spraying is considered the standard practice in most fruit regions. Dusting will frequently suffice as a control program for apples and pears when the orchard is coming into bearing, but in mature orchards, dusting is limited chiefly to supplementary applications for scab control when it is not feasible to use sprayers. Growers who own dusting machines in addition to sprayers use the sprayer during the dormant and early foliage sprays, then employ the duster during summer applications, or hold it as an insurance and safety factor against an emergency need. In large orchards, dusting as supplementary to spraying or between sprays is considered a sound practice where the length of time to complete a spray is too long to give adequate control. However, if the apple or pear planting is not extensive enough to justify ownership of both a sprayer and a duster, the grower might well place his dependence on spraying.

The dusting of peaches, plums and sweet cherries for control of brown rot has produced good results and is highly recommended in most states when properly timed. Here again, however, the enterprise must be large enough to justify the ownership of both a duster and a sprayer. A duster cannot be used effectively for dormant control of insects and diseases of stone fruits.

The advantages of dusting are briefly as follows: (1) The job usually can be accomplished more rapidly; 30 acres of mature apple trees or 40 acres of peaches may be dusted in a ten-hour day with a modern power

TABLE 34

QUANTITY OF DUST TO USE PER PLANT AT EACH APPLICATION

(Adapted from Beach and Childers)

CROP[1]	AGE OF TREES IN YEARS				
	1 to 5	5 to 10	10 to 15	15 to 20	20 and over
	Ounces	*Ounces*	*Ounces*	*Pounds*	*Pounds*
Apples	2	4–8	16	1½–3	3–4
Cherries	2	4	8–12	1	1–1½
Peaches	2	4–8	8	½	½
Pears	2	4–8	8–12	1	1
Plums and Prunes	2	4	8–12	1	1

[1] Amount of dust required for currants, gooseberries, and grapes is about 2 ounces per plant.

duster. This is four or five times the acreage that can be covered by a modern sprayer, other than the Speed or air-blast rigs which may be equally rapid but involve greater initial expense. (2) The labor requirement is less. Large dusting outfits may be operated with one-third less manpower than a large sprayer (other than Speed or air-blast types). (3) The water requirement in spraying is eliminated and no time is lost in hauling water or filling the tank. Sufficient materials for half a day of work can be carried on the dusting machine. (4) Power dusting equipment is light. A loaded duster weighs less than an empty sprayer. The equipment can be used when the ground is soft, rough, or too steep for practical operation of sprayers. (5) Dust can be applied when the fruit and foliage are damp from dew or light rain. Spraying should be done when the plants are dry. (6) Standard dusting materials are less caustic to fruit and foliage than some sprays. Thus, better finish of the fruit is usually obtained with dusting. (7) Investment per number of trees is less with a duster than with a sprayer. (8) Dusting materials may be removed from harvested fruit by brushing or dry polishing, whereas sprayed fruit often requires washing to sufficiently reduce the residue. (9) The hand dusters are more convenient and less expensive than hand sprayers for home fruit gardens.

The chief disadvantages of dusting are (1) materials for dusting are more expensive than for spraying; however, the greater expense of dust materials may be partially offset by the labor-saving factor in dusting; (2) dusting has very limited use during the dormant period; control of insects and diseases during this period is largely done by spraying; and (3) for most insects and diseases and under most conditions, better control is usually obtained with spraying than with dusting, As stated previously, dusting has generally given satisfactory control of insects and diseases on stone fruits during the growing season, particularly brown rot. However, inasmuch as dusting is not effective for dormant-season control of insects and diseases on fruit trees, it must take second choice to spraying which is effective in both dormant and growing-season applications.

CONTROL MEASURES OTHER THAN SPRAYING AND DUSTING

Natural control measures. A common and important means by which insects and diseases are controlled are natural factors which operate without the assistance of man. These include inherent resistance of the species, or immunity; environmental conditions, as unfavorable temperature, moisture and light; and the natural plant and animal enemies of horticultural pests, included under the subject, "Biological Control."

Different varieties of the same fruit exhibit different degrees of resistance toward insect and disease pests. The exact cause or causes of resistance and immunities are not known but certainly some of them are hereditary. Different degrees of resistance will be exhibited by the same kind of plant at different seasons of the year, and by different parts of the same plants in different stages of growth and development of the plant or plant parts. Natural factors which may contribute to the immunity of a plant to attacks by plant and animal pests are thickness of the cuticle and cell wall, the size and abundance of stomata and lenticels, the presence or abundance of hairs and other physical structures on the plant, and numerous other factors may contribute to resistance. Growth and germination of fungi may be inhibited on some plants because of their chemical composition. Likewise, such a plant may be repellent or even toxic to insect pests and be a barrier to the development of bacterial and virus diseases. It is generally true that a moderately vigorous plant is more resistant to insect and disease attacks than a weak one. The most rapid progress in developing resistance in plants to animal and plant pests is through crossbreeding and selecting by mutations.

Sooner or later, almost all insects and diseases have natural enemies which prey upon them so that a natural system of checks and balances exist. Shortly after cottony-cushion scale was introduced into the United States, it became a serious pest to orchards until its natural enemy, the lady bird beetle, was introduced, after which the scale pest was reduced to one of minor importance in fruit orchards. Entomologists are on continual lookout for predatory insects which can be propagated and disseminated for the purpose of reducing major insect pests of fruit crops. The pomologist, as well as the entomologist, encourage the perpetuation and multiplication of birds, fungi, bacteria, and insects that aid in keeping the plant and animal pests of fruit plants under control.

Artificial control measures. There are several physical means of controlling insect pests and diseases, namely, (1) destroying or burning the diseased plant or portion of a plant, (2) mechanical guards, (3) soil cultivation, (4) sanitation, (5) crop rotation, (6) official nursery inspection of propagation material, and (7) sterilization of pruning tools and the pruning wounds where disease portions have been removed.

Many pests of orchard crops overwinter in plant refuse, such as dropped leaves and fruits, weeds and other plants about the trees and along fence rows. These harboring areas should be cleaned up and burned each dormant season, which also lessens the danger of mice and rabbits. Disposal of cull fruits by burying or similar means is highly important in controlling insects and diseases. Also, sanitation around the packing shed is important to prevent spring emergence of codling moths harbored over winter in old boxes, crates, and packing rooms. Old boxes should be placed in a tightly closed room and fumigated to kill adhering cocoons.

Some insects and diseases, such as the Oriental fruit moth of peaches, the grape berry moth, and brown rot of diseases, are partly controlled by spring disking or plowing which buries and destroys the overwintering stages. Curculio populations are also reduced by spring and early summer disking.

In Chapter IV on "Soil Management of Apples," it was shown how wire guards around the base of trunks of the trees are helpful in reducing mouse and rabbit injury.

About the only effective control available for some pests and diseases is roguing and destroying affected plants. An example is cedar rust of apples which can be controlled by the removal of cedar trees, if not too numerous, within a radius of one or two miles from the orchard. Other diseases controlled by roguing are crown gall of nursery stock and mosaic diseases of brambles and peaches. Crop rotation is often effective with strawberries in reducing a buildup in leaf diseases. Pruning away infected parts and disinfecting the wounds is effective in checking fire blight of pears and apples.

Official nursery inspection service is highly effective in reducing the dissemination of diseases and insects from nurseries. This inspection is required by most states as a protection to the fruit growers and other buyers in the state.

Review Questions

1. List the 3 types of insects (based on mouth parts) found in fruit plantings.
2. What groups of diseases are found in orchards and small fruit plantings?
3. Give the two general and important types of insecticides used for controlling the insects listed under question 1.
4. What are the main differences between straight lead arsenate and basic lead arsenate?
5. What are the main differences between calcium arsenate and zinc arsenate? Give examples of fruit insects against which they are used.
6. In what fruit region have the cryolites been used most in orchards, and why are they used in place of lead arsenate?
7. What are the advantages and disadvantages of the nicotine bentonite sprays in the apple spray schedule?
8. Give 3 common fruit insects controlled by contact insecticides.
9. List 3 popular contact insecticides.
10. Give the common orchard insects which DDT will and will not control. Why do some orchard pests increase when DDT is used in the spray program?
11. What is the purpose of dinitro compounds when mixed with petroleum oil for dormant spraying?

12. What is the advantage, if any, of miscible oils over concentrated or mayonnaise-type oil emulsions?
13. What is the chief advantage of tank-mix oil spray?
14. What two chemicals continue to be the best and most widely used fungicides in fruit growing?
15. What is the difference between liquid-lime sulfur and dry-lime sulfur?
16. Why do wettable sulfurs cause little or no burning of apple foliage as compared with liquid-lime sulfur?
17. What is meant by a 6-8-100 Bordeaux mixture?
18. Briefly describe a method for preparing 6-8-100 Bordeaux mixture.
19. What are the advantages of fixed copper compounds over Bordeaux mixture?
20. On what fruits are fixed copper compounds frequently used?
21. What are the 2 types of plungers used in power sprayers?
22. What is the purpose of the pressure regulator and describe briefly how it works.
23. Give the parts of a disk nozzle and state briefly the purpose of each.
24. What effect does varying the depth of the eddy-chamber have on the type of spray cone?
25. What effect does an increase in pump pressure have on size of spray droplets and angle of spray cone?
26. What type of spray tank and agitator paddle require the least power for an equal amount of agitation?
27. How do you account for the popularity of the power take-off orchard sprayer?
28. Describe the air-blast sprayers, giving advantages over conventional portable rig with guns and brooms, and over the spray mast.
29. What are the advantages of a tower mounted on the portable spray rig?
30. What is the quickest method for refilling a portable orchard sprayer?
31. What are the advantages of stationary spray systems and under what conditions are they best adapted?
32. What are the advantages of dusting over spraying? The disadvantages?
33. Under what conditions is the purchase of a power duster advisable in deciduous fruit growing?
34. Give pertinent recommendations for effective spraying of mature apple trees with a modern portable power sprayer, using guns or brooms, or both.
35. Describe how to thoroughly dust a mature apple tree with an orchard power duster.
36. How much dust is necessary to cover a mature peach tree?
37. Describe how the spray service of the state agricultural extension service may operate to assist the fruit grower in using the correct materials at the critical time.
38. Describe equipment necessary for night spraying and when is such spraying advisable?
39. Considering all factors in the purchase of spray materials, which of the following materials should be used for scab control, assuming that:

    (*a*) Lime-sulfur costs 22 cents per 100 gallons, may reduce leaf area 25 per cent, and control scab 100 per cent.
    (*b*) Wettable sulfur costs 48 cents per 100 gallons, may reduce leaf area 0 per cent, and control scab from 50 to 100 per cent.

(*c*) Flotation sulfur costs 48 cents per 100 gallons, may reduce leaf area 5 per cent, and control scab 90 to 100 per cent.
(*d*) Bordeaux mixture costs 14 cents per 100 gallons, may cause russeting and injury, and control scab 85 to 90 per cent.

40. Under what conditions do copper and sulfur cause foliage injury?
41. What is meant by a cover spray?
42. What methods other than spraying and dusting are effective in reducing insect populations?

Suggested Collateral Readings[1]

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[1] Catalogs from spray equipment companies are valuable for study and comparison of the various types of equipment on the market. Companies include: John Bean Manufacturing Co., E. Lansing, Mich.; Dobbins Manufacturing Co., North St. Paul, Minn.; A. B. Farquhar Co., York, Pa.; Friend Manufacturing Co., Gasport, N. Y.; Hardie Manufacturing Co., Hudson, Mich.; H. D. Hudson Manufacturing Co., Chicago, Ill.; Messinger Manufacturing Co., Tatamy, Pa.; The F. E. Myers and Bros. Co., Ashland, Ohio; Niagara Chemical Division, Food Machinery Corp., Middleport, N. Y.; and Root Manufacturing Co., Cleveland, Ohio.

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CHAPTER XVIII

Judging Contests and Exhibitions

Most students develop a special interest in fruit judging and identification contests. This is particularly true where the competition is keen and cups, medals, or cash prizes are awarded. In many states, apple judging contests are held for vocational agriculture students, usually in conjunction with the annual winter farmers' meetings at the local agricultural colleges. In Ohio and New York, for example, these contests are held during Farm and Home Week in January or February when over 100 teams may compete for individual and group prizes.

An example of competitive contests among colleges is the Eastern Inter-Collegiate Fruit Judging League which consists of teams from several eastern colleges of agriculture. A similar league is active in the Middlewest. Teams are trained during the fall to enter a contest early in December. Meeting place of the contest is rotated among the respective colleges, which gives the students a good opportunity to become acquainted with fruit growing in other states and the research and student programs of the respective horticultural departments. These contests also bring the students "closer" to the apple and develop in them a real interest in the growing of fancy fruit. They also acquire a keen ability to identify common varieties of apples, which, in the opinion of most growers, is the first prerequisite in commercial fruit growing.

Most emphasis in the following discussion on fruit identification and judging will be placed on the apple, since it is used almost exclusively in fruit judging contests. Once a student has become an expert with the apple, he can quickly become proficient with other fruits.

Identification of fruit varieties. In training for a fruit judging contest, probably the first and most important step is to study and drill persistently on the detailed ways of identifying each variety included in the contest. A team member who is weak in identification of varieties may lose heavily in a contest, not only from incorrect identification, but also from incorrect placing of plates, because these two phases of the contest are interdependent, as pointed out later.

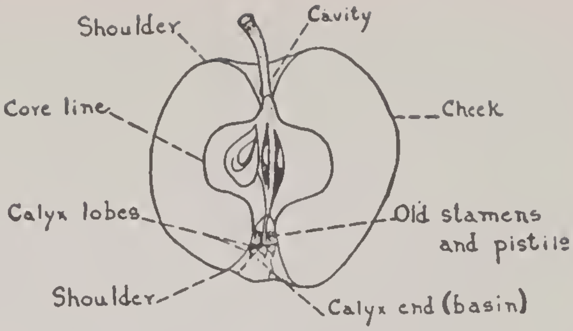

Figure 229. Parts of an apple used in varietal descriptions.

The identification of an apple variety can be done with almost the same precision as a criminal can be spotted by his finger prints. To do this, however, the identifier must be thoroughly acquainted with the different parts of an apple considered in identification (Figure 229) and the several variations of these parts, each of which is typical for a given variety. This may sound difficult at first, but after a little study, it becomes easy and, in fact, intriguing. When the beginner first looks at an apple, he usually sees only a few obvious differences between varieties, such as size and color. Although usable, these characteristics are often the least reliable for identification purposes. There are numerous other external characteristics which receive more weight in making a final decision and naming a variety. Even though one characteristic of an apple may be clear-cut and true-to-form, one should rarely base final decision on one characteristic alone, but consider several which are more or less typical of a variety. The last resort in identifying an apple is to cut it in half and study the flavor, color, and texture of the flesh, and numerous other internal characteristics, but this is not feasible in competitive judging contests. Therefore, only the external characteristics used in identification are discussed below.

Form or shape. If an apple variety is viewed from the cheek side, it may have one of several distinct shapes, as shown in Figure 230, or it may have a shape intermediate between two or more of these apple outlines. Likewise, the terms given for the respective forms may be used singly or combined for description purposes.

When an apple is viewed from the stem end or the calyx end, it may be placed in one of three types: (1) regular, (2) compressed, or (3) ribbed or angular (Figure 230). Here, again, the apple in question may not fall distinctly in one or the other of these types; it may fall between.

Skin. The skin of different varieties when studied externally may have several variations. The *surface* may be waxy, oily, or waxen (resembling a wax model); rough or smooth; bright or dull; roughened underneath, or russeted on the surface. Although the *dots* may appear similar for several varieties, on others they may be outstandingly different. Dots are one of the more reliable characteristics upon which to base judgment. The dots may be conspicuous or inconspicuous; many or few; minute, small, or large; rough, sunken (pitted or depressed), submerged (visible and enlarged under

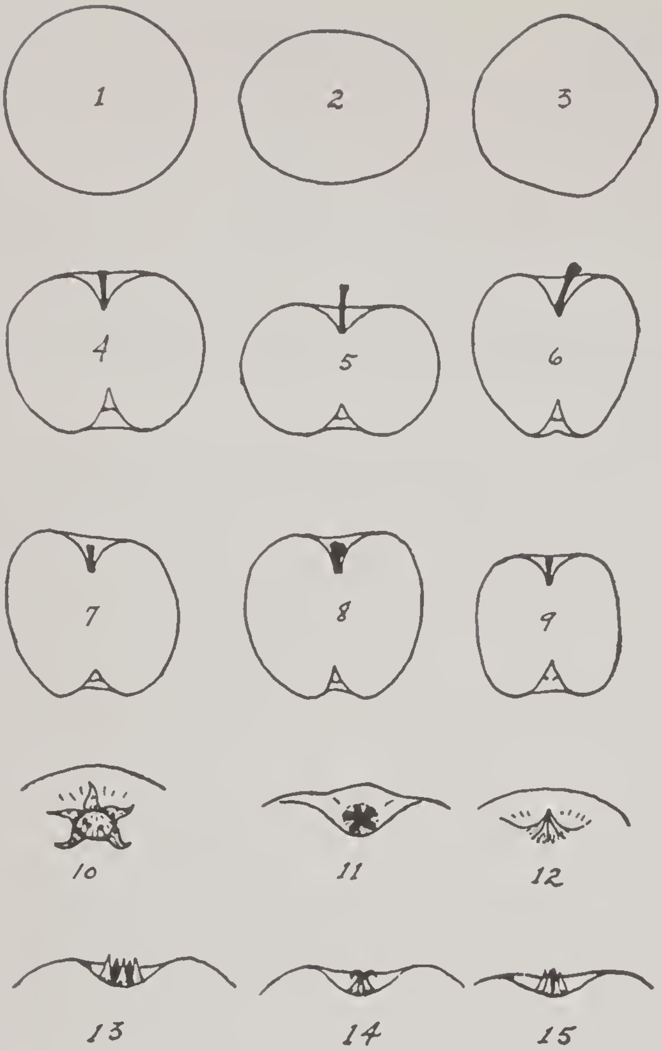

Figure 230. Common apple characteristics helpful in identifying varieties. Apples viewed from stem end may be, *1*, regular; *2*, compressed; or *3*, ribbed or angular. Apples viewed from the side may be, *4*, round or ball-like (Wealthy); *5*, oblate (Wagener); *6*, conic (Delicious); *7*, round with oblique axis (York Imperial); *8*, round-oblong (Baldwin); and *9*, truncate (Grimes Golden). The calyx lobes may be, *10*, widely reflexed or divergent; *11*, flat convergent (wide open calyx); *12*, conelike or connivant with lobes slightly overlapping and forming a cone; *13*, erect convergent; *14*, connivent with reflexed tips; *15*, similar to *12* with lobes loose at tips. The cavity of apple No. *4* is acuminate; No. *5*, obtuse; and No. *6*, acute. The stem of apple No. *4* is erect and medium in thickness and length; No. *5* is medium thick and long; No. *6*, medium length, leaning, and clubbed at both ends; No. *8* is short and clubbed at tip; and No. *9* is medium thick and short.

the epidermis); stellate (star-shaped or triangular), haloed, or areolar (surrounded by a halo of paler color); numerous or scattered at the calyx end; or elongated.

Some varieties may have what is known as *scarf skin* which consists of whitish flecks underneath the cuticle. Stayman Winesap is a good example. The scarf skin may be conspicuous or inconspicuous, located largely at the stem end or calyx end, or in lines, stripes, patches, or flecks. *Bloom* which is a powdery waxy film over the cuticle surface may be used for identifying apples which have received but little handling since harvest. The amount of bloom varies with the variety. It may be absent, faint, inconspicuous, conspicuous, or abundant. After the fruit has been handled by several people in a contest, however, this characteristic is lost.

Color. As stated previously, color is not too reliable, although it is always considered in identification. The *ground* or *undercolor* of a variety may be green, yellow, whitish, orange, or intermediate between these colors. The *surface,* or *overcolor* which is usually red or some blend of red, may be washed, blushed, splashed, striped, or mottled with pink, pinkish-red, brownish-red, crimson, carmen, scarlet, or other colors. The standard Stayman, for example, is usually a pinkish-red, whereas the standard Arkansas may be a dull brownish-red.

The *stem end* of the apple is one of the more important characteristics to consider. The angle of the cavity may fall in one of three distinct shapes, as shown in Figure 230: acuminate, acute, or obtuse. The cavity may be narrow, wide, or medium in width; or shallow, medium, or deep in depth. The angle of the shoulder may be smoothly rounded or it may be abrupt. The skin markings in and around the cavity may be russeted, roughened or smoothed, or with radiating or concentric lines. The contour of the skin in the cavity may be ridged, furrowed, regular and smooth, or lipped. A cavity is lipped when a portion of the skin and flesh at the base of the stem protrude up and against the stem.

The *stem* may vary within a variety, but it is usually fairly reliable. As shown in Figure 230, the stem may be slender, thick, dry, or fleshy; it may be long, medium, or short. Some varieties have a clubbed stem which may be enlarged at tip end or both ends. Some stems may stand upright while others lean.

The *calyx end* of the apple is as important as the stem end for identification purposes. It may be narrow, medium, or wide, and somewhat U-shaped. It may be deep, medium, or shallow. The shoulder may be round or abrupt. There may be characteristic markings, such as russet and discontinuous concentric rings. The outline of the basin may be round, elliptical, or angular. The contour of the skin may be smooth or irregular, ridged, ribbed, wavy, wrinkled, corrugated with protuberances, or it may be crowned with five more or less distinct points on the shoulder as commonly found with the Delicious.

Weight and firmness. Some apple varieties such as Winesap and Arkansas when held in hand are distinctly heavier and firmer than others such as Wealthy and Gravenstein. The weight characteristic is often used in identification, as is also the firmness factor which is determined by holding the apple in the palm of the hand and using uniform pressure with the full hand. *Do not use the thumb* alone for determining firmness.

Size. The general run of apples of a given variety may be small (two and one-half inches in diameter or below), medium (about two and one-half inches), above medium to large (three and one-half inches), or very large. The Grimes Golden tends to run medium or below, whereas the Tompkins King runs medium to large. The size characteristic, however, may vary considerably with the size of the crop, the fruit region, and cultural conditions under which the crop was grown. Therefore, the size characteristic is not so reliable.

Calyx. The calyx may be open, partly open, or closed. The five calyx lobes may be green and succulent or dry, or separated or together at the base, connivent (upright tips come together and form an inverted cone), divergent, reflexed, reflexed at tips only, or folded over each other.

After the identifier has become well acquainted with each variety, he may discover characteristics other than those listed above, such as odor, that to him may be equally helpful in identification. Students with sensitive noses have been known to almost attain a 100 per cent proficiency in identifying apples on the basis of odor alone. The odor characteristic is of little value, however, if the apples are cold.

Probably the best procedure in learning to identify a number of apple varieties is to take only two or three varieties at a time, preferably those which tend to resemble each other and which may be confused in a contest. If a group of students are meeting for one or two hours a day for three or four days a week, it might be well to attempt to master from five to seven varieties a week. Identification quizzes involving 50 to 100 or more apples should be given regularly, adding new varieties periodically and always including the old varieties. After the students have developed a fair skill in identifying all the varieties on the list, they can then begin to turn attention to judging classes, but it is important to continue to hold identification quizzes along with the judging. The deformed or immature apples from the cull pile are difficult to identify and, therefore, should be used freely after the students have begun to master the salient points of each variety.

Although commercial apple growers have reduced their varieties to only a few, it is not uncommon to see on the market and in home gardens a persistence of old varieties which are considered "tops" among the old-timers. For this reason, the rules of the Eastern Inter-Collegiate Fruit Judging League have maintained a list of 25 apple varieties for the contest. With vocational agriculture teams, however, where less time is usually given to training judging teams, the variety list may be reduced to 12 or 14 of the common commercial varieties.

As an aid to the student in learning to identify the 25 apple varieties, a brief description is given below, covering only the more typical characteristics of each variety. It should be emphasized that although these characteristics hold in the majority of cases, they may be obscure in some instances. Here, again, the identifier must base his final decision on several characteristics and not one.

1. *Arkansas*[1] (Mammoth Black Twig or Paragon). Round to oblate and regular in shape, oily skin, dull olive green undercolor, dull to brownish-red overcolor, short- to medium-length and medium-thick stem, connivant reflexed calyx, heavy weight.
2. *Baldwin.* Round and regular in shape, oily skin, dull brownish-red overcolor, pitted dots especially around calyx end, calyx frequently open with lobes separated at base, short stem occasionally swollen at the tip. Study character of smooth medium-wide and medium-depth basin which generally holds true.
3. *Ben Davis.* Conic and regular shape, pinkish-red stripes and splashes of overcolor, yellow to faint yellow undercolor, russet around the stem, medium length to long slender stem, and a very characteristic somewhat

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[1] Descriptions are given for standard varieties only, not the bud sports. Underlined descriptions indicate those which tend to be most reliable.

U-shaped basin with walls often concave in appearance. Study the basin carefully; it is typical and tends to hold true.

4. *Cortland.* Oblate subconic shape and regular, wide U-shaped basin with corrugated protuberances near calyx lobes, calyx frequently open, rough skin, medium to short slender stem, dark blood red overcolor, whitish-yellow undercolor if exposed, wide obtuse cavity, heavy bloom on unhandled apples, and loud characteristic odor resembling McIntosh when warm.

5. *Delicious.* Conic with five more or less distinct ribs and five crowns on the shoulders at the calyx end; stem often enlarged at the base and the tip and usually leaning to one side, usually a bright pinkish-red with a characteristic odor when warm.

6. *Golden Delicious.* Conic and regular shape, grass green to straw yellow depending upon maturity, russet dots which are evidently responsible for relatively quick shriveling of fruit in storage, medium to long slender stem, acute cavity, medium depth and width basin with smooth shoulders.

7. *Gravenstein.* Subconic to truncate, and round to compressed when viewed from stem end, large green leafy calyx lobes folded over each other, smooth waxy skin, straw yellow color with wide stripes and splashes of pinkish-red overcolor, short often thick stem, sometimes oblique axis.

8. *Grimes Golden.* Oblong-truncate and round to compressed, short slender stem, straw yellow to grass green color, tends to shrivel relatively quickly, frequently open calyx with lobes spread apart at base, wide somewhat U-shaped basin, characteristic odor.

9. *Jonathan.* Round conic regular shape, rich red color with frequently straw yellow spots (where leaf rested on the upper shoulder), medium to long slender stem, characteristic wide deep basin with abrupt shoulder.

10. *King David.* Conic regular shape, deep reddish-black color approaching purple, with one or two straw yellow spots frequently present on upper shoulder where leaf rested, medium to small size, medium length slender stem, narrow shallow basin, and with halo dots (dots with narrow light yellow or pinkish fields around them).

11. *McIntosh.* Round conic to oblate regular shape, loud characteristic odor when warm, smooth waxy skin, heavy bloom when unhandled, medium to short slender stem sometimes swollen at tip, medium to narrow shallow basin which is somewhat U-shaped and smooth, acute cavity characteristically grooved.

12. *Northern Spy.* Conic shape with five to ten rather pronounced ribs, smooth medium width and depth basin, stem medium in length and thickness and often clubbed, cavity wide, deep, acute, and abrupt with three distinct furrows often forming a triangular cavity.

13. *Northwestern Greening.* Round to slightly conic and very regular and symmetrical—almost ball-like, characteristic yellowish-green, very smooth skin which tends to become oily, medium length and thickness stem, small acute often compressed cavity, and a characteristic medium width and

smooth-shouldered somewhat U-shaped basin, a relatively large apple, submerged dots widely scattered.

14. *Rhode Island Greening.* Round-oblate and fairly regular, tends toward oiliness, medium-length slender stem, grass green color but occasionally yellowish, large number of submerged dots around calyx end (visible under epidermis), and large size, with concentric russet rings in basin, obtuse shallow smooth basin.

15. *Rome Beauty.* Round conic and regular, but occasionally ribbed, obtuse cavity, usually of characteristic green color, medium to long slender stem, numerous pitted dots at calyx end, reflexed calyx lobes, usually lacking red color around base of stem, shallow narrow smooth basin.

16. *Roxbury Russet.* Oblate conic tending toward compressed and angular with sides unequal, usually russeted although not always, large star-shaped or triangular russet dots, thick short to medium stem usually red on one side, grass green to straw yellow in color, cavity deep acute and sometimes lipped, calyx large and often partly open.

17. *Stark.* Round conic and regular, large apple, usually grass green with dull reddish-brown blush with very characteristic green dots on uncolored areas, medium thickness and length stem, cavity acuminate and often lipped; characteristic shallow and rather flatlike obtuse wrinkled basin—study a typical specimen carefully, it usually holds true.

18. *Stayman Winesap.* Round conic and regular, scarf skin, light conspicuous large dots numerous at calyx end, pinkish color, with characteristic smooth medium width and depth basin.

19. *Tompkins King.* Round and regular, heavy weight, large apple, varying in color from pinkish to dull brownish-red, numerous pitted dots around calyx end, upright medium length and width stem often flared at base and top, somewhat obtuse stem end, skin oily when left at room temperature for sometime, radiation stripes from base of cavity.

20. *Wagener.* Oblate and broadly five ribbed, wide angular acute cavity with medium length and thickness stem, solid pinkish to dull red color, smooth skin, wide and fairly deep furrowed basin.

21. *Wealthy.* Round and ball-shaped, probably most symmetrical apple on the list, radiating stripes from base of stem, medium length and medium thickness to thin stem, wide deep smooth basin, stripes and splashes of red tending toward pinkish color; fruit among the first to shrivel in storage.

22. *Winesap.* Conic and regular or obscurely ribbed, hard flesh and heavy weight, skin oily, narrow width and depth with slightly furrowed basin, calyx lobes connivant and reflexed at tips, usually solid red wine color, but occasionally striped.

23. *Winter Banana.* Subconic to oblate and fairly regular, conspicuous submerged dots congregated at calyx end, very wide obtuse stem end and small shallow calyx end, pale yellow with occasional pinkish blush, relatively

large light weight apple, smooth waxen skin, with a suture line originating at calyx end and running partly or entirely to the stem.

24. *Yellow Newtown.* Round-oblate to truncate and oblique, sometimes compressed and angular, varying from grass green to straw yellow frequently with bluish-pink blush, hard heavy apple, very short often thick stem, skin tending toward oiliness, heavy scarfing on stem end tending to be streaked toward outer edges, usually retains firmness longer in storage than most apples.

25. *York Imperial.* Round and compressed with oblique axis, pinkish to brownish-red color, short stem crowded in cavity, deep stem end and deep abrupt calyx end, hard heavy apple, skin tending toward oiliness, and fruit holding up in storage longer than most apples.

Several of the above varieties may resemble each other so closely that they make good interchangeable substitutes in judging classes. For example, it is not uncommon to find an occasional specimen of Wealthy which is difficult to distinguish from a Jonathan; a Stark apple is frequently substituted in a Stayman Winesap class. One substitution that catches students off-guard is an entirely green specimen of a normally red variety which has been substituted in a class of normally green apples. This can be done with a green Wealthy substituted in a class of green Grimes. Also, an entirely green Stark can be substituted in a class of Rhode Island Greening.

The following is a list of 25 varieties accompanied by two to four other varieties which are interchangeable as substitutes in judging classes.

1. *Arkansas*
    - Winesap
    - Stayman Winesap
    - Baldwin
    - T. King

2. *Baldwin*
    - T. King
    - Arkansas
    - Rome Beauty

3. *Ben Davis*
    - Rome Beauty
    - Jonathan
    - Northern Spy

4. *Cortland*
    - McIntosh
    - Rome Beauty
    - Wagener

5. *Delicious*
    - Northern Spy
    - Rome Beauty
    - Stayman Winesap

6. *Golden Delicious*
    - Grimes Golden
    - N. W. Greening
    - Roxbury Russet

7. *Gravenstein*
    - Grimes Golden (yellow)
    - Wealthy (green)

8. *Grimes Golden*
    - Golden Delicious
    - Gravenstein (no stripes)
    - Wealthy (green)
    - N. W. Greening.

9. *Jonathan*
   - York Imperial
   - King David
   - Ben Davis
   - Wealthy

10. *King David*
   - Jonathan
   - Wealthy
   - Ben Davis
   - Winesap

11. *McIntosh*
   - Cortland
   - Jonathan
   - N. Spy
   - Wagener

12. *Northern Spy*
   - Wagener
   - McIntosh
   - Jonathan

13. *Northwestern Greening*
   - Yellow Newtown
   - Grimes Golden
   - R. I. Greening
   - Roxbury Russet

14. *Rhode Island Greening*
   - Northwestern Greening
   - Yellow Newtown
   - Roxbury Russet
   - Stark (green)

15. *Rome Beauty*
   - Stayman Winesap
   - Cortland
   - Baldwin
   - Tompkins King

16. *Roxbury Russett*
   - R. I. Greening
   - Yellow Newtown

17. *Stark*
   - Stayman Winesap
   - Yellow Newtown

18. *Stayman Winesap*
   - Stark
   - Rome Beauty
   - Winesap
   - Arkansas

19. *Tompkins King*
   - Baldwin
   - Rome Beauty
   - Arkansas

20. *Wagener*
   - Northern Spy
   - Delicious
   - Cortland

21. *Winesap*
   - Arkansas
   - Stayman Winesap
   - King David

22. *Wealthy*
   - Jonathan (green or red)
   - Grimes Golden (green)
   - Ben Davis
   - Gravenstein

23. *Winter Banana*
   - Grimes Golden
   - N. W. Greening
   - Gravenstein (rare)

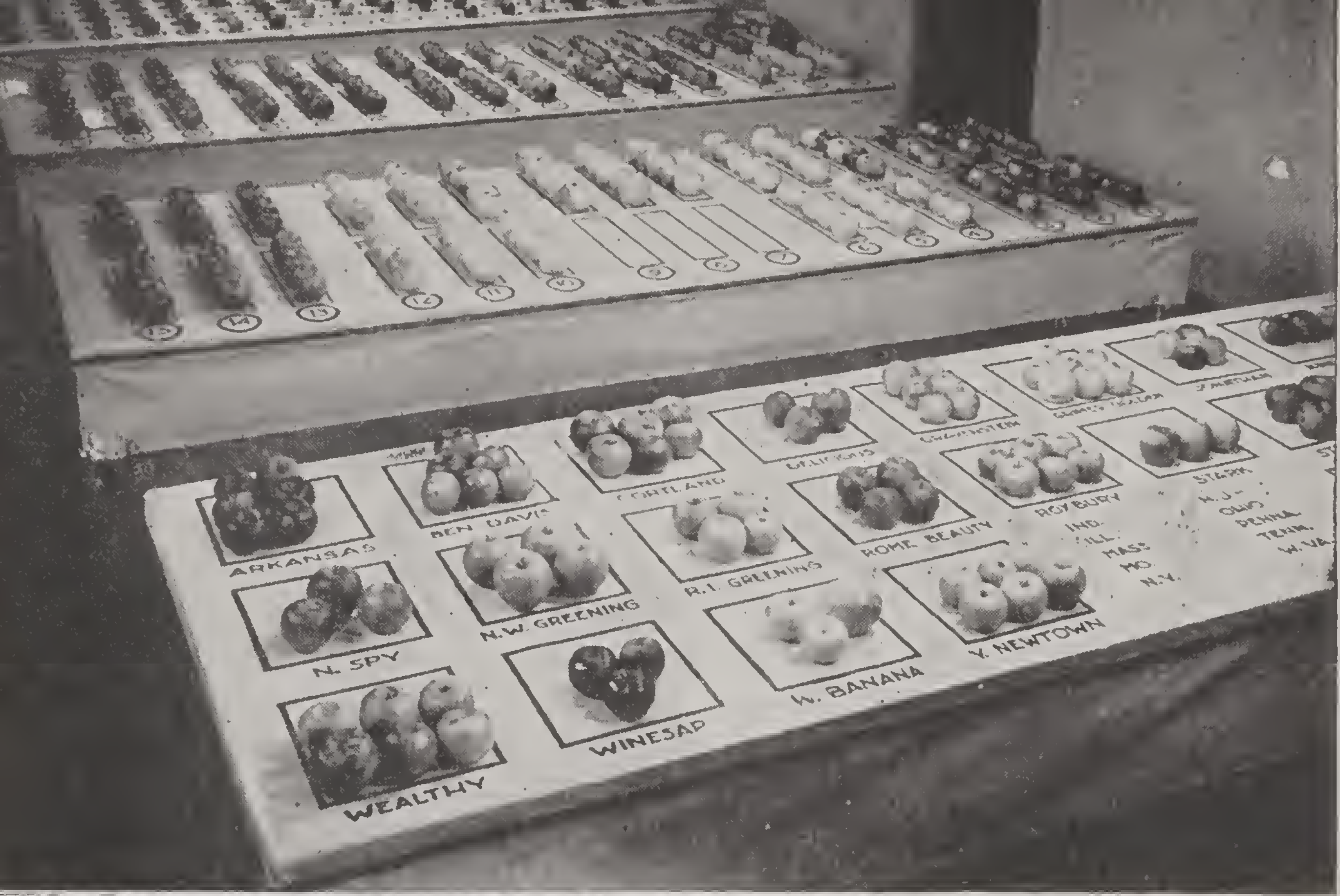
24. *Yellow Newtown*
   - R. I. Greening
   - York Imperial (green)

25. *York Imperial*
   - Yellow Newtown
   - Jonathan
   - Ben Davis

Suggested laboratory equipment and training methods. The laboratory room shown in Figure 231 is especially equipped for training students in identification and judging of apples for the Eastern Inter-Collegiate Fruit Judging League. Any moderate-size well-lighted laboratory room could be used, but for convenience it should be located near the cold storage. The room in the photograph is 13 feet wide by 25 feet long. The tables are special built for fruit judging and identification with tops 3½ feet wide by 8 feet long; they stand 34 inches high and are supported by 4- by 4-inch solid wooden legs. The rigid wooden tops are covered by heavy duck cloth held tightly in place by ½-inch brass stripping around the edges. Beneath the cloth are ½-inch felt pads which serve as a cushion for the apples. The cloth is impregnated with three coats of flat white paint upon which the black enamel lines and figures are painted. An over-all layer of two coats of clear floor varnish helps to protect the black lines from the normal amount of student wear and the soap and water used in cleaning the tops. Good supplemental light, preferably from drop reflectors, is important over the tables; high ceiling lights or light from the windows is often insufficient for detail examination of fruit on dull days. In Figure 231, a 200-watt drop light is provided above the center of each table.

The two center tables in Figure 231 are used for judging of fruit classes. Each table accommodates ten classes of three plates each. The plates are permanently numbered on the table tops from 1 to 30 on one table and from 31 to 60 on the second table. The rear table is used for practice in identification of apple varieties. The table is divided lengthwise by a center black line so that there are 50 numbered circles on one side of the line and 50 numbered circles on the other side. The numbers are arranged so that the student passes around the table only once in identifying the 100 apples. Six to eight students can work around the identification table at one time, using special numbered mimeographed sheets and clipboards, as shown in the student file cabinet in Figure 232. If only six to eight students are present in the laboratory at a time, the instructor can spend five or ten minutes before class laying out the identification apples, and while the students are later identifying them, he can spend his time setting up judging classes on the center tables. After the students have identified the apples, the instructor can check their papers while they proceed to judge the half dozen or more classes on the center table. If about 15 students are involved, the identification and judging apples must be set up before class, and one group of students identifies while the other judges classes. Sufficient time (15 to 25 minutes) should be allowed at the end of the period to discuss the identification and placing.

The top of the table in the foreground in Figure 231 is divided into 25 ten-inch squares on which four to six apples of each of the 25 varieties are placed. The apples may remain available for reference by the students even while they are taking the identification test. The apples are renewed on the table once every week or two, or as the occasion demands it. Toward



Ohio State Student Hort. Society

Figure 231. (Top) Four specially built tables for fruit judging and identification. Two center tables are permanently marked for judging classes, rear table is marked for identification exercises, and the front table contains samples of 25 varieties under study. (Bottom) Training a team of three members and an alternate for the Eastern Inter-Collegiate Fruit Judging League. Each member's placings and reasons are thoroughly analyzed.

the end of the course, the exchange baskets of sample varieties from other states are placed on the reference table for two to four days for examination by the students, after which they are removed and placed on the identification table for the regular identification quiz. The state from which the display apples came is indicated by a portable arrow, as shown in Figure 231.[1]

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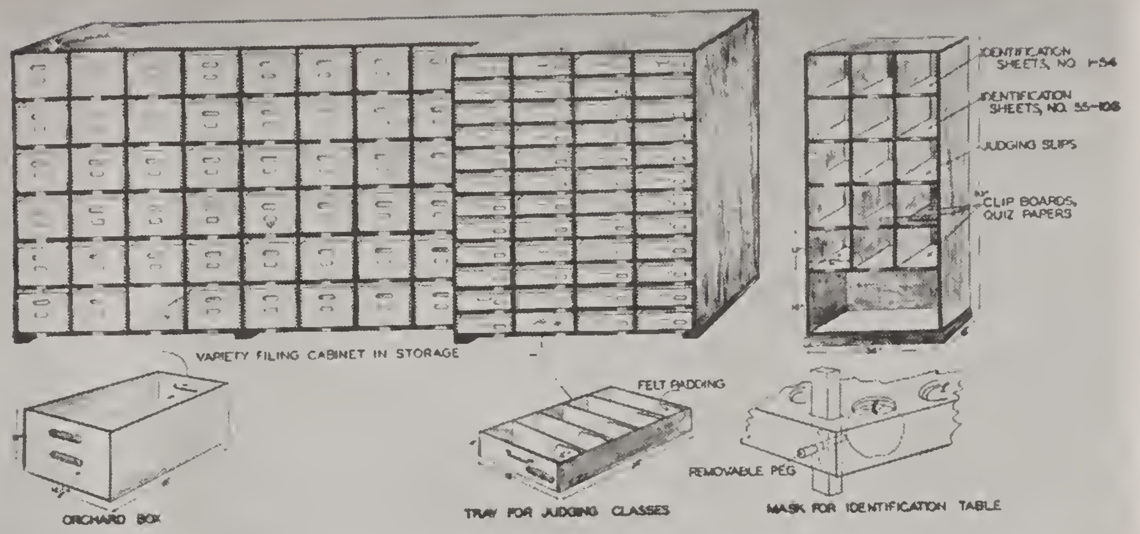
[1] It is the custom for teams in the collegiate fruit judging leagues to exchange a bushel basket of apples which contains from 5 to 10 typical specimens of as many of the varieties entered in the contest as are available. This gives the students at all colleges an opportunity to study the variations that occur within a variety coming from other sections of the country. These variations are marked with some varieties, such as Stayman Winesap and Cortland, making them difficult to identify at first sight. The final contest usually contains an assortment of specimens from all states involved.


IDENTIFICATION SHEETS, NO 1–54
IDENTIFICATION SHEETS, NO. 55–108
JUDGING SLIPS
CLIP BOARDS, QUIZ PAPERS
VARIETY FILING CABINET IN STORAGE
FELT PADDING
ORCHARD BOX
REMOVABLE PEG
TRAY FOR JUDGING CLASSES
MASK FOR IDENTIFICATION TABLE

Ohio State Student Hort. Society

Figure 232. A large cabinet (left) in the cold storage room affords convenient means for filing apple varieties for identification on left and judging plates on the right. Small cabinet (right) contains judging and identification forms and return quiz papers. A mask (bottom right) reveals only a small portion of the apples for refinement in student identification.

In schools where laboratory space is limited and it is not possible to set aside four specially built judging tables, another alternative is to paint the numbers, circles, rectangles, and squares on oilcloth or canvas. The cloth can be cut to fit the tops of the laboratory tables in question and for each exercise can be thumb tacked to the underedge of the tables. After the exercise, the cloth strips can be rolled up and laid aside. This procedure seems more desirable than using chalk on the tables or slips of paper to number the apples and classes, as is often done. Chalk is naturally smeared and the loose paper may blow around and become mixed. In the long run, the system shown in Figure 231 is more convenient for the students and a real time saver for the instructor.

An apple filing cabinet, as shown in Figure 232, is also valuable in fruit judging courses for systematically filing the varieties and judging plates in a near-by cold storage room. Apples are filed in individual orchard boxes labeled by variety; two pigeon-holes, correspondingly labeled, are reserved for boxes containing each of the 25 varieties.

The righthand side of the cabinet is equipped with a convenient number of trays for filing the judging plates. The trays (greenhouse flats) are about 16 by 24 by 4 inches and are divided lengthwise with partitions to accommodate four or five plates. Instead of dismembering the plates after a laboratory exercise, as is often done, the individual plates are kept intact in the trays and filed alphabetically by variety in the cabinet. The No. 1 plates for classes, so-designated by the instructor, are filed together by variety in one group, as also are the No. 2 and No. 3 plates. Thus, it is possible in succeeding exercises to quickly prepare judging classes by jumbling and rejumbling the plates. Apples in both the orchard boxes and trays can be kept in better condition by mixing shreaded oil paper with them while in storage.

In the Eastern Inter-Collegiate Fruit Judging League, the students are given about eight to nine weeks of training, beginning the first week in October in order to prepare for the contest held around the tenth of December. The first three or four weeks are usually devoted to identification exercises. When the students feel that they have "completely mastered" the characteristics of the 25 varieties near the end of the course, the identification apples are covered by a mask, as shown in Figure 232. The mask is large enough to cover about one-third of the table top. The legs at the corners of the mask can be adjusted up or down to fit the size of the apples. When three masks are used at one time on a table, one mask covers the large apples, another the small apples, and a third covers the medium-sized apples. Thus, the student is confined in the identification to only the calyx or stem end or to one side of the apple, which forces him to study detailed characteristics more closely. It is surprising how proficiently some students can identify apples by this system. An alternative to the mask system is to cut off a cheek or cavity or calyx end from the apple and place it on the table, skin up, for the students to identify. By the latter system, however, the fruit can be used only once and the student may tend to base his decision on internal flesh characteristics which are ruled out in competitive contests.

In the last half of a training course, more emphasis is placed on judging, although identification quizzes involving 100 apples are continued each period. At the beginning of the judging exercises, the students are asked to make their placings on the basis of only one point, such as *condition;* the other four points are disregarded. When the significance of (1) *condition,* (2) *color,* (3) *form,* (4) *size,* and (5) *uniformity* of color, form, and size of apples have been introduced separately, the classes are then set up to emphasize primarily but one point, such as condition, although the student must consider all five points in making his final decision. Slow introduction of the five points in judging seems to enable the students to grasp each point more thoroughly with less conflicting ideas of their relative importance.

Considerable time can be saved in setting up judging classes by purchasing Fancy grade apples from near-by leading growers. Sometimes interested growers are obliged to have their grading and packing crew especially select apples for the judging teams. The little extra money paid for these apples is well spent. Four or five good classes may be obtained from a Fancy box of apples.

In selecting a judging class, the box of apples is carefully laid out on the tables with all stems up. An apple of desirable form, color, size and of good condition is selected as a standard for matching with four other apples to make a No. 1 plate in a class. The four other apples are first chosen on the basis of uniformity of size, shape, and color with the standard apple. All stems should be present and uniform in size and shape. The condition of the apples is then carefully inspected and those weak in condition are replaced by better apples. After about six plates of a variety have been so selected, obviously some plates will be slightly better than others on one or more of the points considered on the score card. A class of three plates is then set up so that there is a top plate, a second plate which is not as good as the top plate but better than the third plate. As indicated on page 478, *condition* takes top consideration, with uniformity next, followed in order by color, form, and size. If in the judges' or coaches' opinions, the top plate of a class is not definitely better than the second plate, a mechanical injury can be made on an apple in the second plate, or an apple can be replaced by a poorer specimen to lower the plate in uniformity or condition. Likewise, some adjustment may then need to be made in the third plate. Another alternative is to enter a substitute specimen in a plate or two plates which, according to the rules, eliminates those plates as far as placing is concerned. Thus, by carefully juggling the apples, several difficult and interesting classes can be arranged.

Competitive interest among the students can be maintained by posting the daily student grades for identification and judging on a bulletin board in the judging room. Summary scores are recorded at the end of each week. The three highest ranking students at the end of the course compose the judging team and the fourth highest man is the alternate, if an alternate man is allowed to attend the competitive contests. (See sample of apple judging contest rules at end of this chapter.)

Fruit tree and orchard judging. Toward the end of a course in pomology, a worthwhile laboratory can be arranged for judging dormant trees, or, trees in leaf, of the apple, peach, plum, cherry, or others. This gives the student an excellent opportunity to apply his acquired knowledge of good or bad scaffold arrangement of limbs, proper amount of shoot growth, prevalence of fruit buds, the detection of diseases or insects and other important characteristics in judging the value of trees for heavy production of high-quality fruit.

In the beginning, a mental picture of an ideal tree should be established on the basis of previous class and laboratory instruction. The next step is to train the eye to weigh or evaluate the various tree factors in order to properly estimate their deficiencies, if any, as compared with the ideal tree. Two score cards are presented on pages 474 and 475, which can be used in competitive contests, one for judging the orchard tree and the other for judging the orchard as a whole. A class of three trees or three adjacent orchard blocks can be set up by the instructor for student judging.

It may aid the students for the instructor to select one of the better trees at the outset, and evaluate the tree by discussing the desirable or undesirable points. Indeed, the economic value of a tree can be judged as accurately as the economic value of a steer, hog, or other livestock.

EXHIBITING FRUIT

Assembling fruit for exhibit. In order to win or stand high in a fruit exhibition, the grower must first raise fancy fruit by the best orchard practices.

TREE SCORE CARD

(Adapted from Duruz)

Factors	Values	
	Bearing Trees	Nonbearing Trees (1–4 yrs.)
1. Size:		
a. Height of tree	15	15
b. Spread of branches		
c. Circumference of trunk		
2. Framework:		
a. Number of primary scaffolds—3 to 4	15	20
b. Height of primary scaffolds—24 to 30 inches from ground		
c. Distribution—6 to 10 inches apart		
d. Number of secondary scaffolds—5 to 7		
e. Height of secondary scaffolds—3 to 5 feet from the ground		
f. General symmetry of tree—vase-shaped or modified leader type		
3. Pruning:		
a. System should be in accord with length growth—severe, moderate, or light	15	
b. Fruiting wood evenly distributed		
c. Interfering branches and dead wood removed		
d. Pruning cuts properly made and treated		
4. Vigor:		
a. Dark green and large leaves	15	25
b. Sufficient new wood past season		
c. New wood in good condition—not spindling		
5. Fruitfulness:		
a. Amount and condition of fruiting wood	20	
b. Amount and condition of fruit buds, blossoms, or fruit		
c. Yield—amount and quality		
6. Health:		
a. Fungous or bacterial diseases	20	40
b. Insect pests		
c. Physiological diseases		
d. Mechanical injury		
e. Sunburn		
f. Frost injury		
Total	100	100

Proper pruning, spraying, and soil management all play vital parts. Fruit thinning is of special importance in promoting size and color.

The exhibition fruit should be picked when firm-ripe and handled with extreme care. Ten times as much fruit probably should be harvested as will be used in the exhibition in order to provide a wide choice for uniformity in size and shape of fruit. Sometimes several bushels of the best fruit are needed in order to select only a few high-quality plates. If the orchard has been well sprayed and managed, fruit in the top of the tree is usually the most desirable, having better and more uniform size and color.

Early varieties should be picked when firm-ripe and held in cold storage

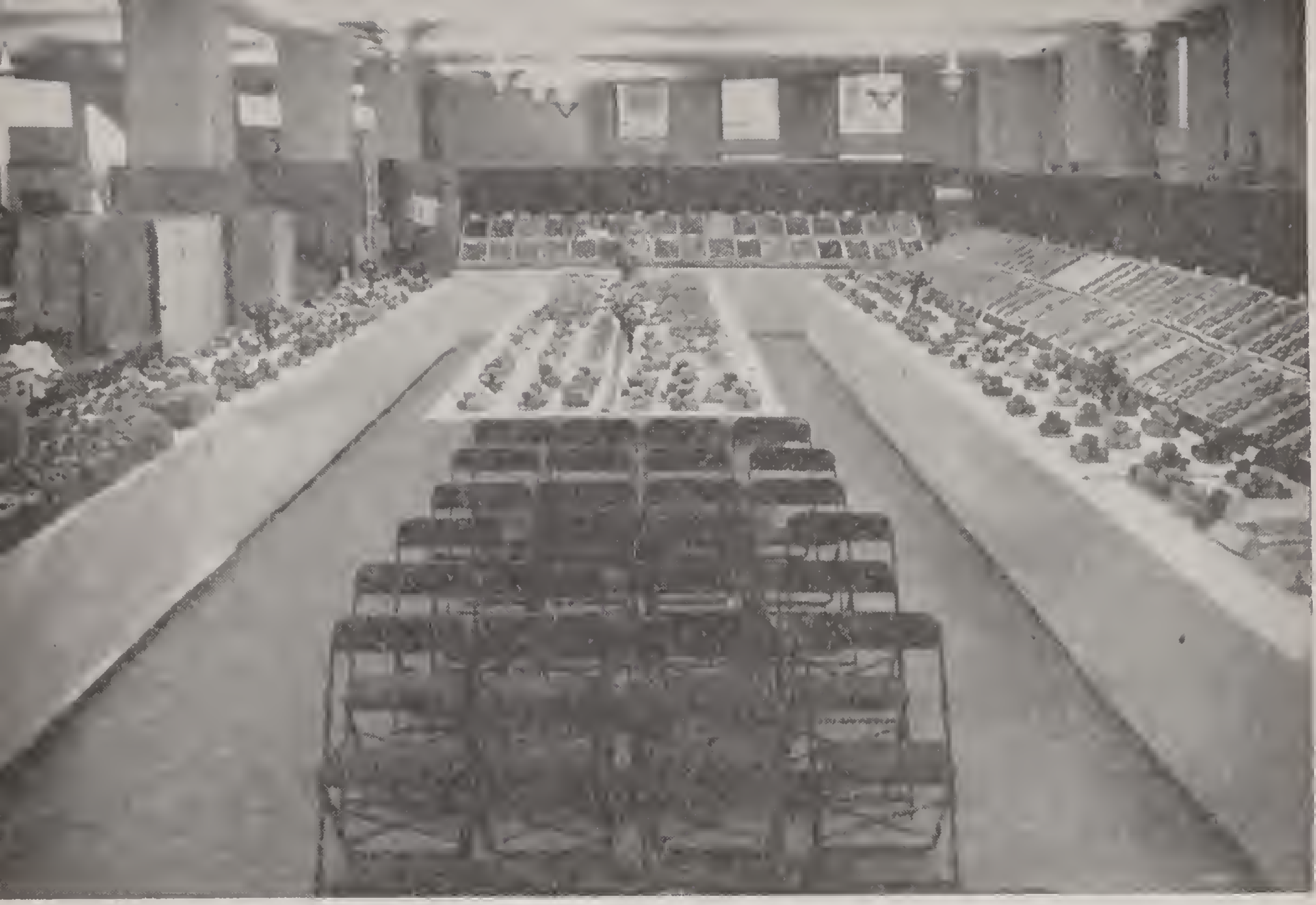
Orchard Score Card

(Adapted from Duruz)

Factors	Values
1. Orchard environment:	
A. Location	10
1. Climate—desirable average temperature, sufficient sunshine and rainfall, free from frosts, fogs, and severe winds.	
2. Transportation—good roads; near to shipping point.	
B. Site	15
1. Water supply—irrigation water supplied by well or ditch.	
2. Slope of land—gradual fall to allow air drainage and irrigation, no swales or low places.	
3. Windbreaks—necessary if winds are severe.	
C. Soil	15
1. Surface soil—medium loam with sufficient organic matter.	
2. Subsoil—deep, well drained, and retentive of moisture.	
2. Condition of trees:	
A. Size—sufficient for age and species, uniform stand	5
B. Fruitfulness—(past yields) present prospects of a crop	10
C. Vigor—sufficient for age and species	10
D. Health—free from sunburn, disease, insects, mechanical injury, etc.	15
3. Cultural Practices:	
A. Soil Care	10
1. Cultivation—soil in good tilth, free from weeds.	
2. Irrigation—sufficient to keep soil wet to a depth of at least six feet.	
3. Cover crops—preferably legumes to maintain organic matter and nitrates.	
4. Permanent sod—often preferred for mature orchards, particularly on slopes.	
5. Fertilization program.	
B. Tree Care	10
1. Planting distance—to provide enough space for spread of trees when full grown.	
2. Pruning—framework and fruiting area well formed, trees open to light, and cuts properly made, moderate in amount to accord with vigor.	
3. Spraying—adequate program for pest control.	
4. Bracing—central wire brace (usually best where bracing is necessary).	
5. Repairing—trees requiring surgery should be treated.	
6. Sanitation—weed and rubbish piles should be removed and rodents destroyed.	
7. Heating—number and kind of heaters per acre.	
Total	100

if necessary. The use of shredded oil paper is effective in maintaining condition and avoiding bruising. If the fruit must be shipped to the exhibit, the egg-cell corrugated boxes prominently stamped with "Handle Carefully" signs are desirable. Apples should be well padded regardless of whether they are shipped by rail or taken in the owner's car. In making the final selection of specimens for a contest, the exhibitor should follow closely the score card rules.

Arranging the exhibit. The fruit is the major attraction in an exhibit and, therefore, all decorations and background should be subordinate in color and design. A neutral color background, such as a medium green, is often



F. H. Beach, Ohio State University Agr. Ext. Serv.

Figure 233. A neat, well-arranged county apple exhibit held in a Cleveland department store. Note plates in the center of the room are on flat tables while banked trays are around the sides. Cooking school and fruit grower's meetings were held in connection with show.

used because it does not compete for attention with the fruit. Shades of green are particularly desirable for red fruit. Burlap in a dark tan is often good with either the yellow, green, or red fruit. Display tables four to six feet wide are desirable, but they should not be so wide that it is difficult to reach the center fruit.

For a large-room display of fruit, it is best to have all fruit in the center of the room on tables at the same level (Figure 233). Fruit next to the walls can be banked with leaning trays from one to as many as ten or twelve trays high. Special racks will be necessary for high banks of trays. It is considered poor judgment to place fruit on shelves at different levels with burlap or paper draped from each shelf. Standard eight-inch rough rolled-edge paper plates are better for displaying fruit because they are stronger and lack gloss. The fruit in each plate should be arranged uniformly. The standard system is for four apples to be placed stem up in the plate with the fifth apple resting stem up in the center on each of the other four. Five pears or peaches are placed on their sides with all stems toward the center of the plate, or, the fifth specimen may be placed in the center on top of the others. As many plums or cherries are placed on the plate as necessary to complete one layer. Stems of the outer ring of plums may be neatly placed toward the center of the plate. Three bunches of grapes complete a plate. Berries are usually displayed in small packages such as pint boxes.

The plates should be aligned perfectly, both across and lengthwise of the table. Leave a small space of about three to four inches between plates so that the background more or less frames the plate of fruit.

Labels for the plates or packages should be subdued in the background. Small white tags about one and one-half inches high by two and one-half inches wide are convenient. They should contain the name of the variety, exhibition class, and the grower's number. The grower's name, orchard, and town can be inserted after placement by the judge. This information is often of interest to other exhibitors and the general public. Tags which give only the entry number at fairs and competitive displays are meaningless to the public. The tags should be placed uniformly at the rear of the plates away from the observer. Special pin holders may be used to attach the tags to the plates.

All plates of the same variety should be placed together following an alphabetical arrangement by variety. The judge or the general public can then easily find the varieties in which they are interested.

Although the plate is a popular display unit, the box flat or tray which is essentially an apple box cut down so as to hold one layer of fruit is very popular. Tub bushel baskets are also used. Apple pyramids involving about one-half bushel of apples each are occasionally seen.

A glossier finish of the fruit can be obtained by polishing with a dry cloth. Although the polishing destroys the natural bloom, unpolished fruit may be at a disadvantage in competition with polished fruit. The practice of fruit polishing is usually covered in the rules governing the exhibition.

Scoring fruit. A score card is useful for a time by the judge in order to impress the relative importance of the different points. Eventually, however, the judge will lay the score card aside and unconsciously take the different points into consideration in ranking the exhibits. Actually, the score of a plate or a package of fruit is usually of less importance than its relative rank when compared with the other plates or packages. Judges may vary considerably in the amount of cut they give on the different points; yet, if both judges are consistent, the final ranking will be about the same. Judging is usually done on a comparative basis. Some entries may be eliminated immediately and without examining them at all, because it can be seen at a glance that they are outclassed by other entries.

When using the score card, cuts are made on a percentage basis. This is advisable because otherwise, the mind, tending to deal with whole numbers, will make too heavy a cut on less important items on the score card and too moderate a cut on the more important items. For example, on the usual score card as given here for apples, a cut of two points on size is a 20 per cent cut, while a cut of two points on condition is less than a 7 per cent cut.

RULES FOR EASTERN INTERCOLLEGIATE FRUIT JUDGING LEAGUE[1]

1. Each team shall consist of three men who shall be undergraduates working

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[1] Original rules altered somewhat in 1941 by coaches of Eastern Intercollegiate Fruit Judging League in order to conform with new problems arising in contests.

for a degree from the institution they represent, and who have never served previously as a contestant in this league. No alternate team member shall start in a contest until the number of regular contestants is reduced to six.[2]

2. Three plates each of twenty varieties (with possible substitutions), making a total of sixty plates, will be selected for judging from the following list of varieties. All 25 varieties may or may not be used in the contest.[3]

Arkansas (Mam. Black Twig) (Paragon)
Baldwin
Ben Davis
Cortland
Delicious
Golden Delicious
Gravenstein
Grimes Golden
Jonathan
King David
McIntosh
Northern Spy
Northwestern Greening
Rhode Island Greening
Rome Beauty
Roxbury Russet
Stark
Stayman Winesap
Tompkins King
Wagener
Wealthy
Winesap
Winter Banana
Yellow Newtown
York Imperial

3. In the final ranking of contestants, 100 points will be given to the *correct placing* and 100 points for the *correct identification* of the three plates of each class.

4. The placing of the plates will be based upon the following standard score card:

Form	10
Size	15
Color	20
Uniformity	25
Condition	30

Form:	In judging form, typical forms for the variety will be considered.
Size:	In judging size, the most acceptable commercial size shall be considered as the ideal. (Allowance should be made for regional climatic influence. A New England Jonathan is smaller than one grown in Illinois or the Northwest.)
Color:	On uncolored apples, green or yellow, a blush will not be considered favorable or otherwise. Golden Delicious, Grimes Golden, Northwestern Greening, Rhode Island Greening, Yellow Newtown, and Roxbury Russet will be considered as uncolored varieties.
Uniformity:	This refers equally to uniformity of color, size, and form. Uniformity is of special importance because if it is lacking, the plate receives a double cut. For example, if form of an apple is off-type, a cut is made under "form" and another cut is made under "uniformity of form" among the five apples in a plate. The same is true for color and size. This is probably double jeopardy, but it is warranted by the importance of the factor.

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[2] Scores of alternate team members are not officially considered in the contest.

[3] This variety list may be altered to better conform with varieties typical of a region.

Condition: Heavy cuts shall be made for the following major blemishes when sufficient to detract from the appearance or keeping quality of the fruit: Codling moth, apple maggot, scab, leaf roller, blotch, cedar rust, scale, Jonathan spot, Baldwin spot, physiological diseases, entire absence of stem, breaks in the skin, and excessive shriveling or bruises not secured by handling the fruit during the contest.

During a contest, the fruit must in no instance be bruised or altered in any way by the contestant.

Actual scoring of fruit will not be insisted upon, but any contestant who so desires may score the fruit and score cards will be provided for the purpose.

5. Each plate will be numbered serially from one to sixty. Individual apples on each plate will be marked with the plate number and the letters "A," "B," "C," "D," or "E." The three plates of a variety will be given consecutive numbers. Thus, the apples on Plate 5 will be marked "5-A," "5-B," "5-C," "5-D" and "5-E."

6. One entire plate, parts of one or two plates, or one entire plate and part of another plate may be substituted in any variety.

(*a*) In plates partly substituted there will never be more than one substituted specimen per plate.

(*b*) No substitute will be selected from varieties other than those mentioned in Section 2.

7. Plates wholly or partly substituted *shall not be considered in placing,* even when two plates are substituted. The penalty for so considering any plate shall be 10 points, when the other plates are correctly placed and the substituted plate is placed last; if placed other than last, 0 for placing.

8. In the identification of a class containing substitutes, the name of a class shall first be given and then the name and number of the substitutes. Thus, the record of a Ben Davis group might be as follows: Class: Ben Davis, Plate 11, is a Baldwin (substitute); 12-E is a Stayman Winesap.

9. The ranking of a contestant in identification will be as follows:

For correct identification of the three plates of each variety, including all substitutes, if any..100

For the correct identification of two plates of each variety, including substitutes, if any..66

For the correct identification of one plate of each variety, including substitutes, if any..33

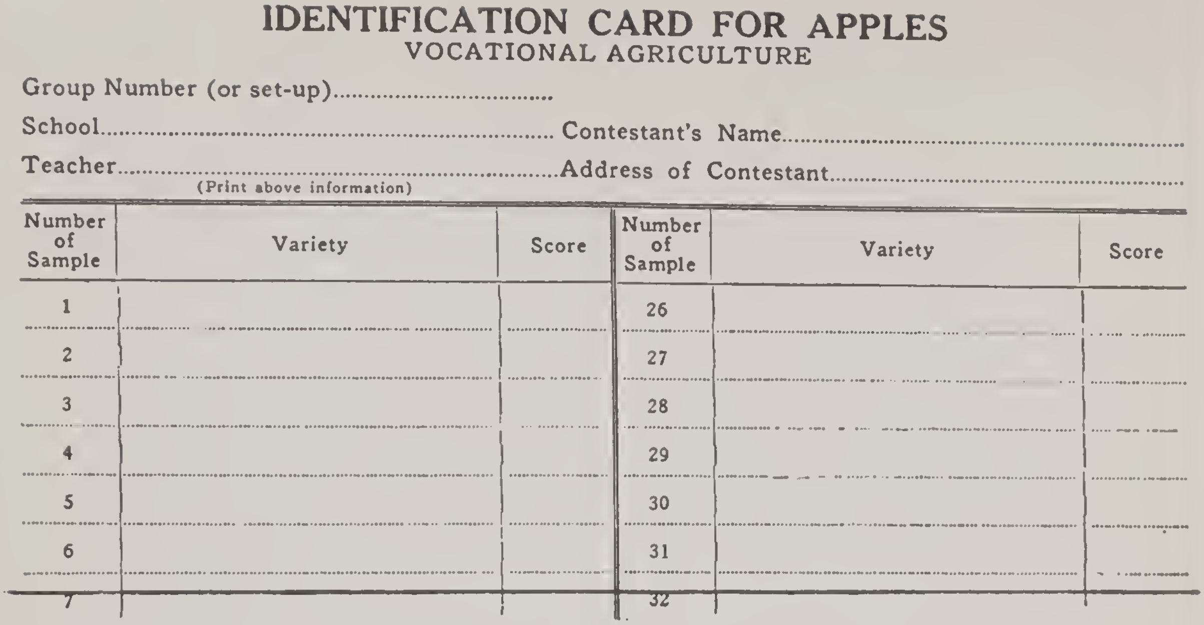
Failure to correctly identify any of the three plates..........................0

A plate containing a specimen substituted shall not be deemed correctly named unless both the variety and substitution are correctly named.

10. In judging, the plate numbers must be used in order of placing. Thus, in the case of judging plates which are numbered 4, 5, 6, the order of placing by the contestant might be 5, 6, 4. The contestant shall so designate on his blank.

The ranking of contestants on placement of plates shall be determined on the following basis (The correct order of placing is 1-2-3):

1-2-3	100	2-3-1	40
1-3-2	80	3-1-2	20
2-1-3	60	3-2-1	0



IDENTIFICATION CARD FOR APPLES

VOCATIONAL AGRICULTURE

Group Number (or set-up)..................................

School.. Contestant's Name..

Teacher..Address of Contestant..

(Print above information)

Number of Sample	Variety	Score	Number of Sample	Variety	Score
1			26		
2			27		
3			28		
4			29		
5			30		
6			31		
7			32		

Ohio State University, Dept. of Agr. Educ.

Figure 234. Identification and placing cards used in vocational agriculture apple judging contests at Ohio State University. To simplify handling of large numbers of high school contestants, no substitute varieties are included in judging classes; variety identification is held separately.

The ranking of a contestant when substitutes are involved shall be determined upon the following basis:

(*a*) When a variety contains one substitution which is recognized by the contestant and the other two plates are placed in correct order, the contestant receives 100. If the two plates are not correctly placed, contestant receives 0. If the substitution is not recognized and is placed the contestant receives 50, if other two are in correct order; if other two are not in correct order, 0. If one substitute is named when not present and the others are placed in correct order, the contestant receives 50; if not in correct order, 0.

(*b*) In case two plates are substituted and are recognized, contestant receives 100. If only one is recognized and the plate containing no substitution is placed first, contestant gets 50; if the plate containing no substitution is placed other than first, contestant gets 0. If neither of the two substituted plates are recognized and plate with no substitution placed first, contestant gets 25. In the case that two substitutes are named when not present and the first plate is correctly placed, contestant receives 25; if not correctly placed, 0. Where one substitute is present and two are called, contestant gets 25 if first plate is placed; if second plate is placed, 0. Where class is misnamed, 0 in placing.

11. The ranking of contestant on identification shall be determined by averaging his scores in identification. The ranking of a contestant in placing shall be determined by averaging his scores in placing. The final ranking of contestant will be the average of his score in identification and placing. Final ranking of a team will be determined by averaging the final scores of the three numbers.

12. The judges shall consist of the coaches accompanying the teams, and all must agree upon the placing of a class before it can be used in the contest.[1]

13. Contest begins at 8:00 A.M. Saturday morning and continues until 1:00 P.M.,

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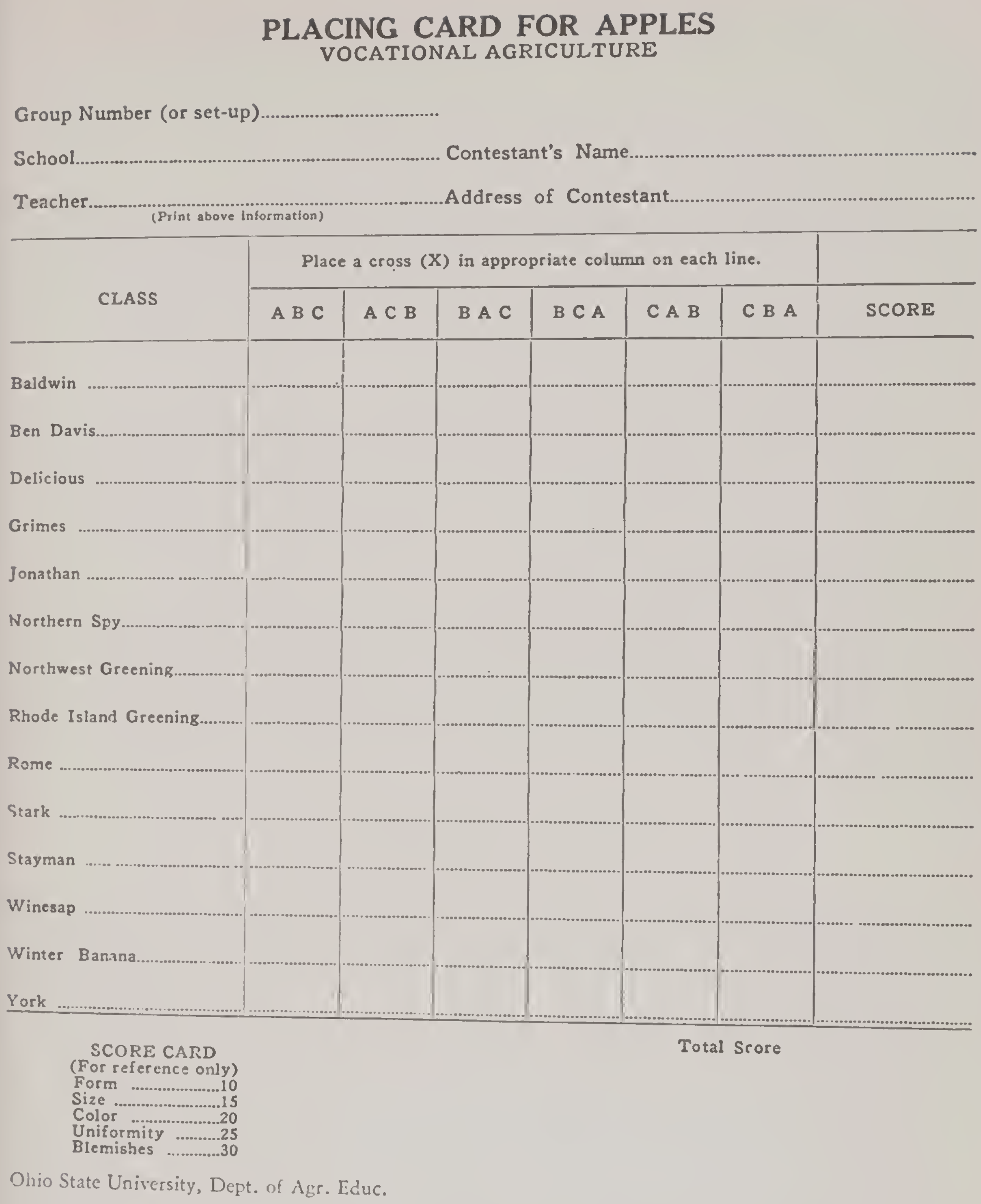
[1] In this League, the coaches and teams arrive on a Friday noon, bring a bushel or two of apples for plates or substitutes, set up the contest Friday afternoon and evening.



PLACING CARD FOR APPLES
VOCATIONAL AGRICULTURE

Group Number (or set-up)....................................

School.. Contestant's Name...

Teacher.. Address of Contestant..
(Print above information)

CLASS	Place a cross (X) in appropriate column on each line.						
	A B C	A C B	B A C	B C A	C A B	C B A	SCORE
Baldwin							
Ben Davis							
Delicious							
Grimes							
Jonathan							
Northern Spy							
Northwest Greening							
Rhode Island Greening							
Rome							
Stark							
Stayman							
Winesap							
Winter Banana							
York							

Total Score

SCORE CARD
(For reference only)

Form	10
Size	15
Color	20
Uniformity	25
Blemishes	30

Ohio State University, Dept. of Agr. Educ.

Figure 235. Grading of placing cards is speeded up by superimposing a transparent key paper on the high school student's card, including those in which the student places X's.

giving 15 minutes per class for the 20 classes. Score cards are usually graded by 3:00 P.M. when winning teams and high-ranking men are announced.

Special Instructions to Contestants
(Immediately before contest begins)

1. You should be perfectly familiar with all the rules of the contest to aid you in making your decisions.

2. The contestant may write the names of the 25 varieties in the contest on the back of the pad given him for his contest record before entering the contest room.

3. The contestant must handle the fruit carefully. No contestant shall use his pencil to pick around in the stem or blossom end of the apple or alter the apple in any way. To test the solidity of the apple, the use of the thumb *will not be permitted.* Firmness can be tested by exerting pressure with the entire hand on all of the apple.

4. Remember that the apples must be handled by a large number of men and that they soon take on the temperature of the human body and may slightly deteriorate before the next member of your team identifies and places the apples. When a fresh bruise or break in the skin is noticed during the contest, it should be immediately reported to the coaches so that the blemish can be specified on the blackboard and disregarded by all contestants.

5. Teammates must not work next to each other at the tables.

6. If you must leave the room, give your pad to a coach other than your own.

7. While working, keep your pad turned face down. Keep your eyes on the class that you are working on for if you are looking around the room, another contestant may handle an apple in such a way as to make you believe it is something special, and he may be wrong.

8. When you leave a class, *it is your responsibility that the apples are placed in the proper order* with the low number of a class to the left, the high number to the right, and the middle number in-between. The apples will be placed on the table in groups of three plates. Apples "A" in each plate should be left next to you, and "B," "C," "D," and "E" in line with it, and placed consecutively away from you.

Review Questions

1. What are the external characteristics used in identifying an apple variety?
2. Briefly describe, and to what part or parts of the apple do the following terms refer: Haloed, stellate, submerged, and pitted; scarf skin; bloom; ground color and overcolor; acuminate, acute, and obtuse; angular; clubbed; and reflexed?
3. What are the distinguishing differences between: Ben Davis, Cortland, and McIntosh; Baldwin and Tompkins King; Stayman Winesap, Winesap, and Stark; Rhode Island Greening and Northwestern Greening; Wagener and Northern Spy; York Imperial and Yellow Newtown; Jonathan, King David, and Wealthy; Grimes Golden and Gravenstein; and Delicious and Wagener?
4. In apple judging contests, what comprises a plate; a class?
5. What is the order of importance of form, size, color, uniformity, and condition in most apple judging contests? Briefly discuss the meaning of each of the afore-mentioned terms.
6. Give recommendations for arranging an apple exhibit with respect to decorations, background, labels, size of tray and tables, and type of plate.

Suggested Collateral Readings

Drain, B. D. Report of committee on standardization of intercollegiate fruit judging. Proc. of Amer. Soc. for Hort. Sci. 1925.

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Duruz, W. P. Fruit tree and orchard judging. Calif. Agr. Exp. Sta. Cir. 309. 1927.

Gilbertson, H. W. How to prepare and display extension exhibits. U. S. Dept. of Agr. Cir. 385. 1926.

Hedrick, U. P. Systematic pomology. Macmillan Co., N. Y. 1925.

Mulford, F. L. Horticultural exhibitions in garden competitions. U. S. Dept. of Agri. Cir. 62. 1919.

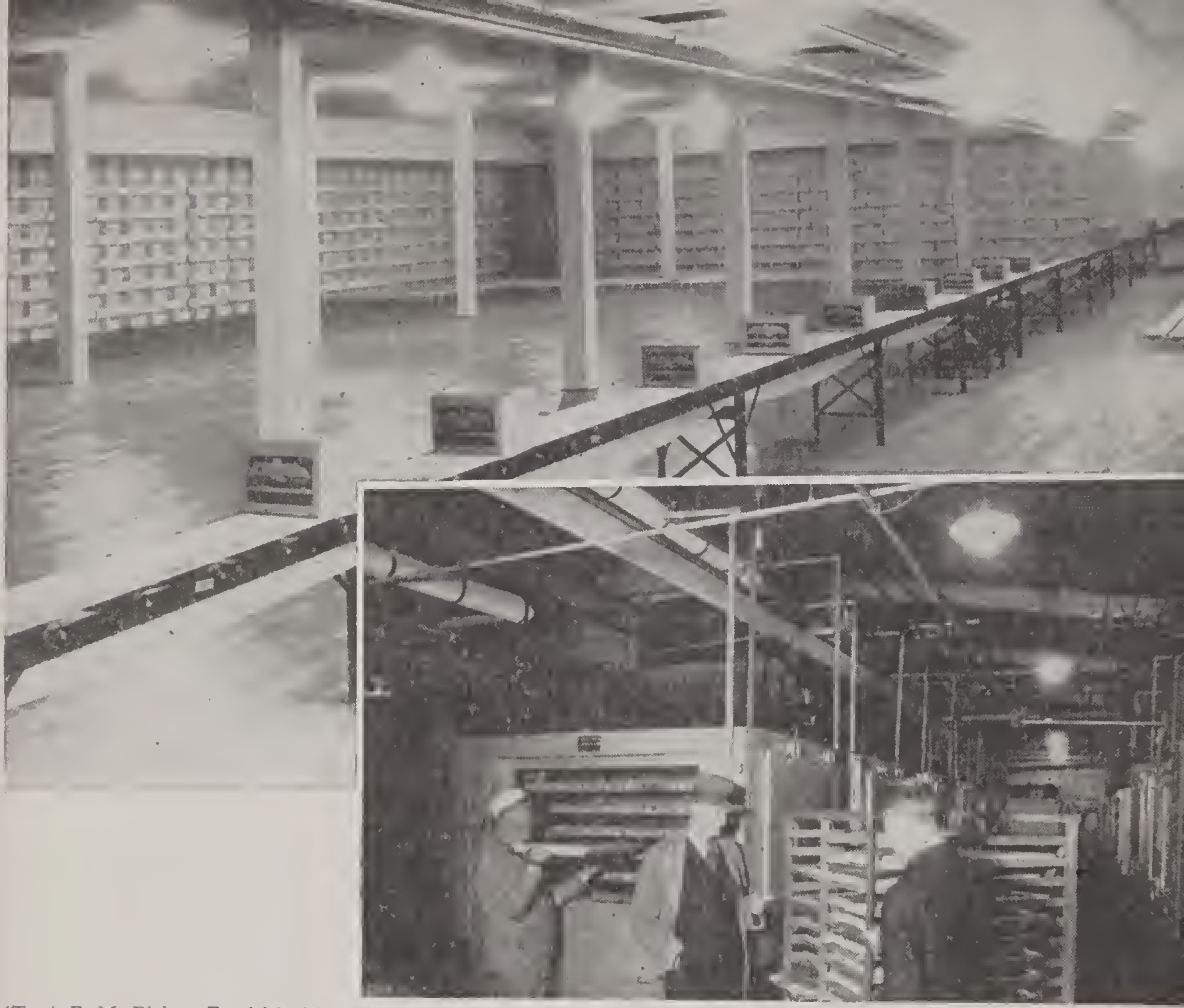
CHAPTER XIX

Freezing Preservation of Fruits

The freezing preservation of fruits by what is termed "cold pack" or "frozen pack" has been used for many years (at least since 1905). It consists of packing hulled and washed fruits with or without sugar in barrels or small containers and freezing and storing at temperatures around 0° F. The products are used as frozen desserts, or in ice cream, pastries, preserves, jams, jellies, or similar preparations. Strawberries and red raspberries are extensively frozen in the Pacific Northwest. A large portion of the sour cherries grown in Michigan and New York are cold packed. Other fruits commonly handled by the frozen-pack method are apples, peaches, apricots, plums, prunes, cranberries, and blueberries. In recent years there has been a rapid almost straight-line rise in commercial freezing of fruits from 70 million pounds in 1936 to over 450 million in 1946. Sugar was the main factor limiting further expansion in freezing preservation during the postwar period.

To what extent the frozen pack will displace cold storage and canning as a method of preservation cannot be predicted, but it is bound to be an important factor. The costs of preparing and freezing fruits may be about the same as the costs of canning, but the costs of transportation, storage, and retail distribution are higher for frozen fruits. Although the higher costs of the frozen pack must be taken into consideration, the higher quality of the product may tend to offset this cost difference from the standpoint of consumer demand. Also, the development of the freezing industry may cause a slight shift of fruit plantings such as strawberries from the high-cost production areas near large cities to low-cost areas where climate and labor conditions are more favorable.

In utilizing the "quick freezing" method of preserving fruits for popular trade, the fruits are placed in small containers and the heat rapidly extracted

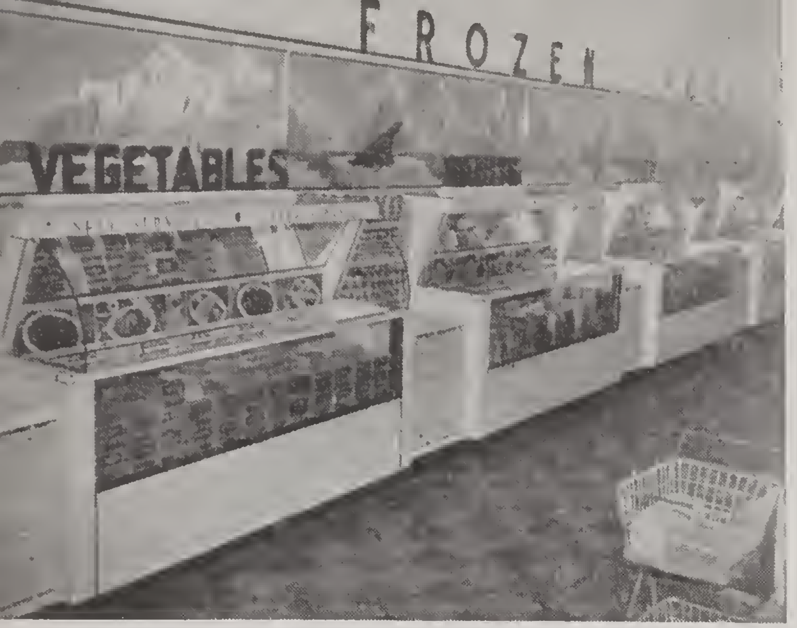


(Top) F. M. Eicher, Food Machinery Corp., San José, Calif. (Bottom) U.S.D.A.

Figure 236. (Top) Large frozen-food terminal in Portland, Oregon, showing storage space and belt equipment conveying Birds Eye produce. (Bottom) A quick-freezing plant showing an assembly of freezing units for strawberries.

from the top and bottom of the packages. The chief advantage of quick freezing is the fact that the ice crystals formed in the product are smaller than those formed by slow freezing and are less destructive to the cell structure. Also, in quick freezing, less time is allowed for diffusion of salts and separation of water to form ice. At temperatures around 0° F., the bacterial, mold, chemical and enzymatic actions are either stopped or minimized. The frozen product upon thawing retains more quality, color, vitamins, and flavor than is attainable by canning. In fact, the frozen product when thawed probably resembles the fresh product more than with any other system of preservation.

Commercially, the frozen-pack method has a definite place in large producing centers where a part of the fruit is bound to become somewhat overripe and too soft for canning or for fresh shipment, but which is wholly suitable for immediate consumption or for freezing. In the Pacific Northwest, as in Louisiana and other major production areas, large quantities of berries are frozen in hardwood barrels, 20- to 30-pound lacquered metal



Hussmann Refrigeration, Inc., St. Louis

Figure 237. Self-service cases containing frozen vegetables, fruits, fish, and poultry in a modern frozen-food store in Boston.

pails, or waxed fiberboard cartons at the height of the harvest season when canners are unable to handle the fruit and when the fresh market is not a profitable one. It is thus evident that the frozen-pack industry has been and is of great value to the fruit industry in providing an orderly and economical means for marketing surplus production.

In recent years, the freezing preservation of deciduous fruits in small one-pound or similar-sized packs has shown a rapid increase in popularity, not only on a commercial basis, but in the private homes. In fact, this method of preservation is preferred to canning by housewives because it is quicker, less trouble, and does not involve standing over a hot stove. Home freezing units are now being manufactured on a large scale to accommodate the marked increase in public demand. Frozen-food locker plants, likewise, have gained considerable popularity over the country. People can rent space in these plants throughout the year for storing frozen meats, fruits, and vegetables.

Frozen food locker plants are of two general types, consisting of either limited or complete service. The private individual may prepare his own products and merely rent space for storing them, or he may bring choice produce to the locker plant where a service charge is made for preparing and packaging it for freezing. Rental for a locker which accommodates the needs of a family of two or three amounts to about $1.00 a month or $10.00 a year. The main objection to locker plants, however, is the inconvenience of a great number of trips to the plant to store and get food. For this reason, it is probable that home freezers or a home freezer-refrigerator combination will become more popular.

A freezing unit which is popular on farms and roadside markets is the walk-in freezer. This type is used where the largest commercially built freezer cabinets do not satisfy the needs. The unit may consist of two rooms, the cooling room and the low temperature room. The cooling room is maintained at a temperature of 32° to 34° F. for storing fresh fruits or vegetables, or for chilling meats or poultry. The inner room opens off of the cooler and is maintained at a quick-freeze temperature of —5° to —15° F. The room is designed to freeze and store rather large quantities of produce. Both rooms contain shelves for holding the packages, and, in some cases, one or two fans to give a strong air blast for rapid cooling. Such a freezer may be built by the fruit grower himself in the apple cold storage room, utilizing the same refrigeration equipment. Or, the unit may be built adjacent to or on the back porch for private use only. Complete instructions for building this type of freezer are given in a special publication from Washington state. In connection with these instructions, it would be well to consult an expert refrigeration engineer to obtain the proper refrigeration machinery and insulation.

Inasmuch as there is widespread interest among fruit growers and gardeners in home preservation of foods by freezing, most of the discussion in this chapter will be devoted to this phase of freezing preservation.

TEMPERATURES FOR FREEZING AND STORAGE

Most bacteria and yeast are inactivated at temperatures immediately below the freezing point of 32° F., but molds may continue to grow slowly at lower temperatures. Chemical reactions continue even at temperatures of —25° F., but the lower the temperature, the slower they take place. Rapid freezing is highly desirable in freezing preservation. The rate of freezing will depend upon the size, shape, and arrangement of packages, air circulation, and contact with the metal tray which aids in the conduction of heat from the articles being frozen. Fruits are often frozen in relatively small cartons which have the advantages of providing good air circulation and faster freezing.

Most locker plants have a special "sharp freezing" room where the products are first frozen, then removed after 8 to 24 hours and placed in the storage lockers at 0° F. or lower. Fruits may be frozen quicker in storage lockers, in case sharp freezing rooms are not available, if a small household electric fan, lubricated with light oil, is placed in the locker. It has been shown that fruits can be frozen more quickly at 0° F. with an air blast than at a temperature 25° F. below zero without the air blast. The containers should be spread out in one layer on the freezing tray in order to obtain good air circulation around each package.

After freezing, it is important that the fruits be maintained at a temperature of 0° F. or less. If held at temperatures above this level, many fruits lose color and darken; also, flavor and vitamin C are sacrificed. This is true for foods held for four months or longer. Lower temperatures are better for keeping fruits in good condition for a much longer period.

Electric power needed. The power required for operating a freezing cabinet depends upon: (1) adjustment of the controls; (2) amount of food frozen; (3) thickness and character of the cabinet insulation; (4) temperature of produce when placed in cabinet; (5) temperature and movement of air in the room surrounding the cabinet; (6) length and number of times the cabinet is opened; (7) efficiency of the refrigeration unit; and (8) the size of the cabinet.

A freezer cabinet of about 12 cubic feet capacity, cooled with a one-third horsepower refrigeration unit, requires from 60 to 100 kilowatt hours per month. The total expense for power would be $1.80 to $3.00 per month if the cost per kilowatt hour is three cents.[1] On many farms the power rate is often lower than three cents. Larger or smaller machines would require more or less power, approximately in proportion to the size of the motor operating the refrigeration unit.

In the freezing compartments of most freezers, the refrigerant passes through the shelves when present and through coils in the walls. The coils are usually covered by metal plates which facilitate removal of the frost. Exposed coils are undesirable because the electrical current must be shut off and the food somewhat warmed in order to defrost the coils. Wide fluctuations in temperature are undesirable with frozen foods. It is important to keep frost removed from the refrigeration surface; otherwise, efficiency of the equipment will be reduced, resulting in slow freezing of the products.

In one type of freezing cabinet, the freezing compartment is surrounded by a metal jacket refrigerated by coils and containing a brine solution which freezes at 5° to 10° below 0° F. This feature is valuable in case of power failure when the frozen solution upon thawing will absorb a considerable amount of heat. Thus a low temperature is maintained for a longer period after the refrigeration equipment ceases operating.

It is important that adequate insulation, moisture-proofed both inside and outside, be provided in order to reduce as much as possible the leakage of heat into the cabinet. Heat leakage increases wear on the equipment and power consumption.

In some locker plants, a small saving in power consumption may be realized by arranging the lockers in tiers of four beneath trap doors in the floor. With an electric hoist, the patron can lift his respective tier of lockers, obtain the food, and lower the tier back into the cold room. This arrangement means that there is little loss of cold by opening and closing large doors and also that the patrons do not need to enter the cold room to use their lockers.

PACKAGES AND WRAPPING MATERIALS

Frozen products should be protected by moisture-vapor-proof wrappers or packages to prevent drying out in the constantly-moving, low-humidity air in freezing storages. Certain types of cellophane are satisfactory for wrapping because they are moisture-vapor-proof, flavorless, and prevent absorption of undersirable odors from the storage room.[2]

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[1] In addition to this cost, the interest on investment, depreciation of the unit, and service charges must be considered.

[2] Among the companies manufacturing satisfactory wrapping paper for frozen products are Detroit Wax Paper Co., River Rouge, Mich.; Dewey and Almy Chemical Co., Cambridge, Mass.; E. I. DuPont de Nemours & Co., Inc., Wilmington, Del.; Good Year Rubber Co., Akron, Ohio; Interstate Folding Box Co., Middletown, Ohio; the Menasha Products Co., Menasha, Wis.; Patterson Parchment Paper Co., Bristol, Pa.; Rhinelander Paper Co., Rhinelander, Wis.; Riegel Paper Corp., New York, N. Y.; Sylvania Industrial Corp., New York, N. Y.

Satisfactory containers for fruits and vegetables are the heavily paraffined paperboard cartons[1] which should possess the same qualities listed above for wrapping papers. Some cartons are of the small rectangular folding box-type with rectangular baglike moisture-vapor-proof liners which are filled with the solid or liquid product, and heat-sealed with an electric iron at the top to make them liquid tight. Single thickness cellophane bags can be used, provided a mesh cloth "stockinette" is placed around them for support; these are available on the market. Heavily waxed cups with slipin or slipover lids are convenient for short storage periods of a few months, but since they are not vapor-proof, the food may dry out, lose vitamins, and darken during long storage periods. This is true when no sirup is used; with sirup they may be quite satisfactory. Round containers, while popular and satisfactory, occupy more space than the rectangular folding cartons of the same capacity. For several reasons, glass jars are generally unsatisfactory for freezing. Tin cans are satisfactory for fruits.

FRUIT VARIETIES FOR FREEZING

Those fruits that give appetizing products when properly selected, prepared, packaged, frozen, and stored are peaches, strawberries, raspberries, blueberries, apples, sweet and sour cherries, currants, and gooseberries. Prunes and plums give fair-quality frozen products when properly selected and handled. Grapes, blackberries, and pears usually do not give satisfactory products by present freezing technique.

The correct variety is most important in freezing preservation. It may make the difference between success or failure. Table 35 gives a list of fruit varieties in representative states of the Northeast, Midwest, and West. New varieties are being added to this list each year, and for this reason it would be well to check further with the local agricultural experiment station.

Strawberries are one of the leading frozen fruits. Varieties that produce the best frozen product are a uniform deep red, firm, and tart. Large coarse berries or pale red varieties of low acidity are usually undesirable. The better raspberry varieties for freezing are firm, deeply colored, and tart. The Montmorency sour cherry variety, in particular, retains color and flavor excellently in freezing. Frozen English Morello cherries give a dark highly flavored product. Duke cherries also retain color well, but the sweet cherries tend to lose some flavor and color in the freezing and thawing process. Yellow peaches retain color and flavor very well, but white varieties tend to darken upon thawing.

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[1] A partial list of manufacturers of frozen food cartons follows: Cup containers: Lily-Tulip Cup Co., New York, N. Y., Nestrite Cups; Mono Service Co., Newark, N. J., E. Z. Cap Kup; Sealright Co., Fulton, N. Y., Sealright Cup.

Folding cartons which require moisture-vapor-proof liners or bags: Container Corp. of America, Philadelphia, Pa.; Interstate Folding Box Co., Middletown, Ohio; Lindley Box and Paper Co., Marion, Ind.; Menasha Products Co., Menasha, Wis.; Michigan Carton Co., Battle Creek, Mich.; New Haven Pulp and Board Co., New Haven, Conn.; Robert Gair Co., Inc., New York, N. Y.; and Russell Box Co., Medford, Mass.

PREPARATION OF FRUITS FOR FREEZING

In case of vegetables, enzymatic action is checked by bringing the tissues to the boiling point with live steam or boiling water (known as blanching). With the exception of apples, this method is undesirable for fruits, because people prefer to eat the fruit raw. Enzymatic action and discoloring of fruits, other than apples, can be satisfactorily checked by covering them with a sugar-sirup which helps preserve their appearance, texture, and flavor. Cranberries require only washing before freezing.

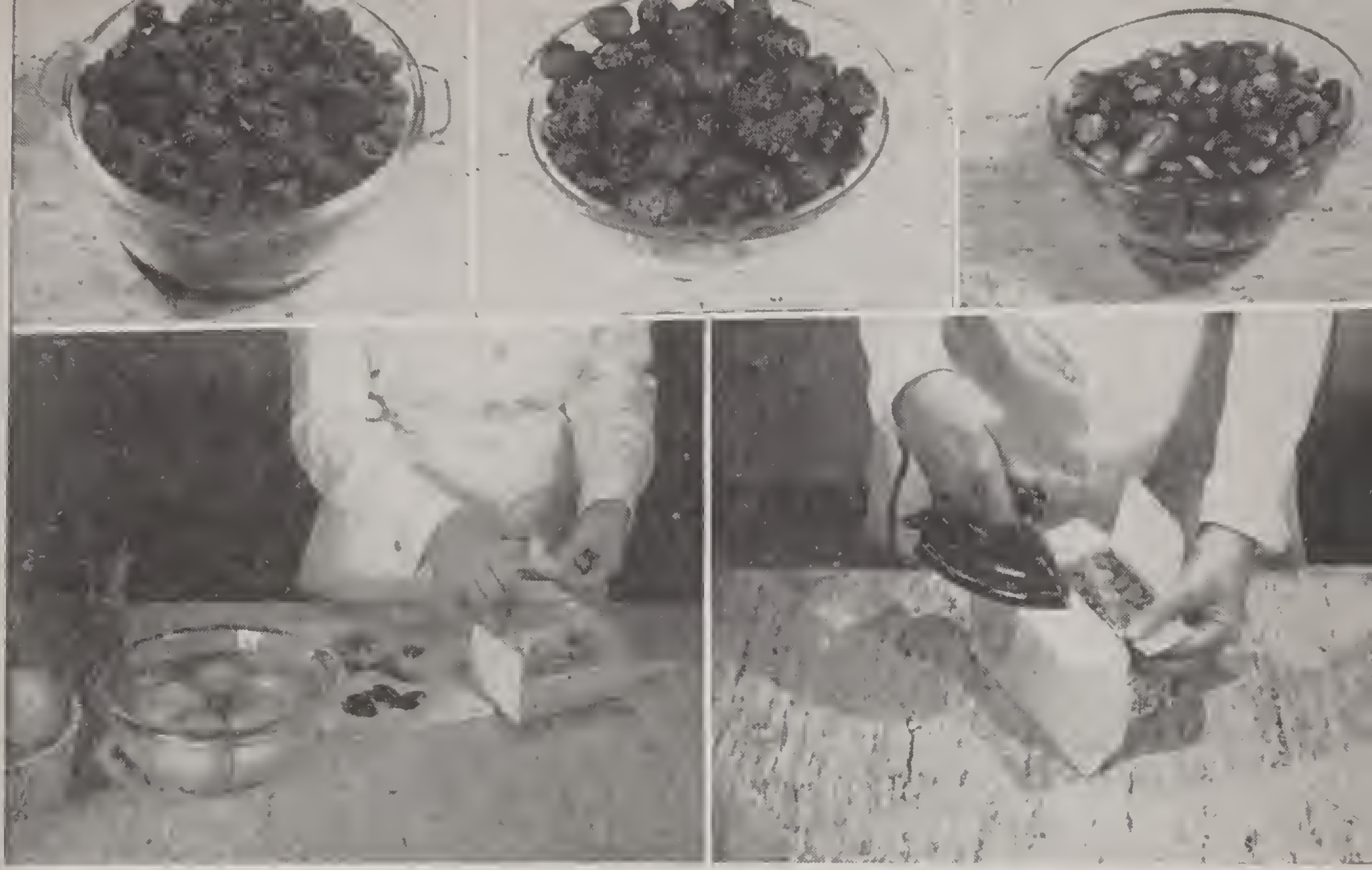
Harvest maturity. Fruits harvested for freezing should be ripened on the plant and be at the best stage of maturity for eating out of hand, but not at the mushy stage. Apples should be firm-ripe since the blanching process will have a softening effect. Green fruit is unfit for freezing. Fruit ripened on the shelf gives a comparatively poor frozen product.

Freeze immediately after harvest. Fruits should be frozen as soon as possible after harvest. Place in a refrigerator immediately at 32° F. to reduce the ripening processes until each batch can be frozen. Only the highest quality fruit should be frozen. Remove the bruised, mushy, rotting, or insect-infested fruits. Thoroughly clean in water containing ice.

Specific recommendations for the preparation of each fruit for freezing are given in Table 36. Note that in case of peaches and apricots, a special treatment with citric or ascorbic acid is recommended to prevent darkening of the tissues. The fruit can be placed in a colander and dipped into the citric acid solution for one to two minutes before packing in sirup or sugar (the sirup pack retains color better than the dry sugar pack). The citric acid solution is made by dissolving one-fourth teaspoon of citric acid in one quart of water. For each bushel of peaches, about one gallon of acid solution is needed. If the fruit is being packed in sirup, a somewhat better but slightly more expensive treatment is with ascorbic acid (vitamin C). One-fourth teaspoon of ascorbic acid is added to each one or one and a half cups of sirup. Both of the above acids can be bought from the drug store.

The sugar-sirup treatment is considered the best for most fruits because the original shape is better retained. Dry sugar is successful with such fruits as strawberries and raspberries, but with a dry meaty fruit, such as peaches, the results are not quite as good. The dry sugar treatment with strawberries, for example, consists simply of adding sugar in the correct amount to the sliced fruit and stirring slowly until most of the sugar has dissolved in the juice that is withdrawn from the fruit tissues. Prepare small batches of fruit at one time. Leave about 10 per cent head space in each container for freezing expansion.

If sugar-sirup is used, the *cool* sirup of the required density is gently poured over the fruit with no stirring, leaving proper head space.



Frigidaire Division of General Motors Corp., Dayton, Ohio

Figure 238. The preparation of fruits for freezing. (Top left) Raspberries are frozen whole with a sugar sirup. (Top middle) Strawberries may be frozen whole with sirup, or (top right) sliced and mixed with sugar before freezing. (Bottom left) Peaches are emersed in hot water, peeled, placed in ice water, pits removed, and cut in twelfths directly into container with moisture-vapor-proof liner. (Bottom right) Liner is sealed with a warm iron on a covered wooden block.

Special funnels are available on the market for holding the moisture-vapor-proof bags and for filling of the bags; or, a homemade funnel can be prepared easily. The container is sealed with a warm iron and labeled to indicate the contents and the date packed. In sealing with the iron, the inside of the bag should be wiped with a clean cloth to remove moisture which may interfere with a tight seal; too much heat may result in an imperfect seal. If a home freezer is not available, the finished packages should be placed in the home refrigerator until they can be transferred to a rented frozen-food locker. It is good practice to arrange the packages in readily accessible groups and to keep an itemized account of all packages of each fruit placed in the freezing cabinet, and all fruits taken out. The accounting sheet can be kept on the wall near the freezer. This gives ready reference to the amount of each fruit available at any one time, eliminating the need for "thumbing" through the packages on numerous occasions.

If the packages are moved to a locker plant, it is essential that they be kept cool and moved rapidly. A temporary insulated box can be prepared by setting a corrugated carton inside a larger one, leaving three to four inches of space for filling with shredded paper, or excelsior. Wooden boxes or tin cans also can be used. In case of corrugated cartons, edges of the insulated box can be sealed with gummed paper. The box can be strengthened by using wooden strips around the outside. A lid can be made by sealing several layers of corrugated paper together with gummed paper.

TABLE 35

VARIETIES OF FRUITS FOR FREEZING IN DIFFERENT SECTIONS OF THE UNITED STATES[1]

FRUIT OR BERRY	NEW YORK			WASHINGTON Approx. order of desirability	OREGON Aprox order of desirability[2]	OHIO[3]	CALIFORNIA[4]
	Excellent	Good	Fair				
Apples	Greening Cortland Baldwin Jonathan Northern Spy Stark	McIntosh Gravenstein		Jonathan Winesap Stayman Esophus (Spitzenburg) Yellow Newtown McIntosh Golden Delicious	Yellow Newtown Winesap Spitzenberg Stayman Jonathan	Jonathan Stayman Baldwin Stark Rhode Island Greening Northern Spy Rome Beauty Golden Delicious Grimes Golden	Yellow Newtown Gravenstein
Blackberries and Dewberries		Eldorado		Boysen (Nectar) Young (Olympic) Logan Cascade Pacific Pacific Coast Wild Oregon Evergreen Himalaya Texas Brainard	Oregon Evergreen Pacific Northwest Wild Blackberry Joy Nersereau Texas Himalaya Lucretia Olympic Young Boysen Nectar Loganberry	Eldorado	Phenomenal and Nectar (Boysenberries)

Blueberries	Concord Pioneer Rubel Rancocas	Wild Highbush Wild Lowbush		Concord Pioneer Jersey June Rancocas Katherine Rubel Harding Cabot Grover Wild sorts	Rancocas June Concord Katherine Jersey Rubel Adams Harding Cabot Grover Sam Alaska		
Cherries, sour	Montmorency English Morello			Montmorency Early Richmond English Morello Late Duke	Montmorency Early Richmond Late Duke English Morello	Montmorency	
Cherries, sweet		Bing Lambert Schmidt Napoleon		Lambert Bing Deacon Napoleon (Royal Anne) Republican	Lambert Bing Republican Tartarian Deacon Royal Anne	Schmidt Bing Lambert Windsor Napoleon	Lambert Bing Napoleon
Cranberries	Early Black Howes			McFarlin Howes	McFarlin Howes Centennial		
Nectarines							Humbolt Tioga Newboy Gowers Stanwick

(Continued on following Page)

TABLE 35

Varieties of Fruits for Freezing in Different Sections of the United States[1]

Fruit or Berry	New York			Washington Approx. order of desirability	Oregon Aprox. order of desirability[2]	Ohio[3]	California[4]
	Excellent	Good	Fair				
Peaches, yellow....	Halehaven J. H. Hale South Haven Elberta Marigold Vedette Veteran Viceroy	Eclipse Oriole Sunbeam		J. H. Hale Gold Medal Elberta Early Elberta Veteran Valiant Rochester (Pacific Gold) Crawford Candoka	J. H. Hale Candoka Gold Medal Late Crawford Elberta Galway Slappey Rochester October Krummel	J. H. Hale Elberta Shipper's Late Red South Haven Halehaven Golden Jubilee Rochester	J. H. Hale Rio Oso Gem Elberta Fay Elberta Early Elberta
Peaches, white.....		Champion Georgia Belle (When packed with Vitamin C)			Carmen	Belle of Georgia Champion (With vitamin C, ascorbic acid)	
Plums	Damson Yellow Egg	Reine Claude				Damson Yellow Egg	Burbank Mithley Beauty
Prunes	Italian Prune (Fellenberg) Stanley Imperial Epineuse			Italian Agen Sugar Imperial Epineuse President	Italian	German Stanley Italian Imperial Epineuse	Italian

Raspberries, red . . .	Milton .Cuthbert	Chief Taylor Viking	Newburg June Latham Marcy	Washington Cuthbert Tahoma Lloyd George Latham Newburg Taylor Herbert Chief	Cuthbert Tahoma Washington Lloyd George Viking Cayuga Latham Newburg Erskine Park St. Regis Ranier Chief King Herbert Antwerp Utah Marlboro	Latham Taylor Cuthbert Viking	Cuthbert
Raspberries, black . .	Bristol		Cumberland	Bristol Cumberland Munger Dundee	Cumberland Plum Farmer Munger Gregg	Logan Cumberland Bristol	
Raspberries, purple .	Columbian Sodus					Sodus Columbian	
Strawberries		July Morn Sparkle Culver Catskill Clermont Chesapeake	Fairfax	Marshall Improved Oregon Brightmore Fairfax Catskill Rockhill Pacific Ray Red Dorsett Narcissa	Corvallis Marshall Clark Seedling Redheart Ray Red Dorsett Ettersburg 121 Narcissa Fairfax	Premier Dorsett Dunlap Catskill Fairfax Blakemore	Marshall Klondike Shasta Banner Sierra Lassen

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[1] Each state agricultural experiment station usually has a list of the better local varieties, obtainable on request.

[2] By correspondence with E. H. Wiegand, Oregon Agricultural Experiment Station.

[3] Brown, H. D. and F. H. Beach. Freezing preservation of fruits and vegetables. Ohio Agricultural Extension Service Bulletin 224, 16–22. 1945. (Revised)

[4] By correspondence with Leonora A. Hohl, Division of Food Technology, Berkeley, California. Other varieties of fruits being frozen in California are Oranges—Valencia; Grapefruit—Marsh; Grapes—Thompson Seedless, Muscat; Dates—Deglet Noor; Persimmons—Hachiya; Figs—Black Mission, Kadota, Calimyrna; Avacoda—Fuerte; Olive—Mission; Apricots—Blenheim (Royal), Tilton, Moorpark, Hemshirk.

TABLE 36

The Preparation of Fruit for Freezing[1]

Fruit	How to Prepare	How to Pack
Apples	Peel, core, and cut into sections of uniform thickness (about 12 sections for medium-sized, more for larger apples to insure sufficient scalding). Scald apples in steam or boiling water 1½ to 2 minutes to prevent darkening. Or if sirup is used for packing you can slice apples directly into it.	Pack in 1 part by weight of sugar to 3 or 4 parts by weight of fruit (1 cup sugar to 5 cups fruit); or in sirup to cover (3 to 4 cups sugar to 4 cups water).[2]
Apricots	Sort for ripeness. Wash, halve, pit, and cut in sections. To keep from darkening, dip for 1 to 2 minutes in a solution of ¼ teaspoon citric acid dissolved in 1 quart water or use ascorbic acid (see How to Pack).	*With citric acid.* Pack in 1 part by weight of sugar to 3 or 4 parts by weight of fruit (1 cup sugar to 4½ to 6 cups fruit); or in sirup to cover (3 to 4 cups sugar to 4 cups water). *With ascorbic acid.* Put apricots directly into sugar sirup to which has been added ¼ teaspoon ascorbic acid to each 1 to 1½ cups sirup.
Berries (except blueberries and strawberries)	Pick over, wash, drain well. Do not wash raspberries unless necessary.	Pack without sugar; or pack in 1 part by weight of sugar to 4 parts by weight of fruit (1 cup sugar to 6 cups fruit); or in sirup to cover (3 cups sugar to 4 cups water).
Blueberries	Pick over, wash, drain well.	Pack in 1 part by weight of sugar to 4 parts by weight of fruit (1 cup sugar to 6 cups fruit); or in sirup to cover (3 cups sugar to 4 cups water; or pack without sugar).
Cherries, sour	Wash, drain, and pit.	Pack in 1 part by weight of sugar to 3 or 4 parts by weight of fruit (1 cup sugar to 4 to 5 cups fruit).
Cherries, sweet	Wash and drain. Pit or not, as desired.	*Pitted cherries.* Pack in 1 part by weight of sugar to 4 parts by weight of fruit (1 cup sugar to 5 cups fruit). *Whole cherries.* Pack in sirup to cover (3 cups sugar to 4 cups water with ¼ teaspoon ascorbic acid added to each 1 to 1½ cups sirup).

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[1] Anonymous. Home freezing of fruits and vegetables. U. S. Dept. of Agr. Leaflets AIS-48. May, 1946.

[2] Sugar sirup should be prepared in advance in boiling water and cooled to 70° F. or lower before using. The sirup can be prepared the day before freezing and held in the refrigerator.

The cartons should be placed one layer deep in contact with metal freezing surfaces, allowing room for air circulation between packages. It is important that the fruits be frozen within a day to avoid spoiling, discoloring, or the development of an off-flavor. Fluctuating storage temperatures should be avoided; a constant temperature around 0° F. is highly important in storage.

TABLE 36

THE PREPARATION OF FRUIT FOR FREEZING[1]

FRUIT	HOW TO PREPARE	HOW TO PACK
Cranberries	Pick over and wash.	Pack without sugar; or pack in 1 part by weight of sugar to 3 or 4 parts by weight of berries (1 cup sugar to 6 to 8 cups berries); or pack in sirup to cover (4 cups sugar to 4 cups water).
Currants	Wash, stem, crush slightly.	Sugar: 3 lbs. berries to 1 lb. sugar.
Figs	Sort, wash, remove stems. Leave whole, halve, or slice.	Pack without sugar; or pack in 1 part by weight of sugar to 4 parts by weight of fruit (1 cup sugar to 6 cups fruit); or pack in sirup to cover (3 cups sugar to 4 cups water).
Gooseberries	Wash, stem, crush slightly	Sugar: 3 lbs. berries to 1 lb. sugar.
Peaches (freestone) and nectarines	Sort, pit, peel (skins may be loosened by scalding whole peaches 15 to 30 seconds in boiling water). Cut in sections. To keep from darkening, dip sections for 1 to 2 minutes in a solution of ¼ teaspoon citric acid dissolved in 1 quart water or use ascorbic acid (see How to Pack).	*With citric acid.* Pack in 1 part by weight of sugar to 3 or 4 parts by weight of fruit (1 cup sugar to 4½ to 6 cups fruit); or in sirup to cover (3 cups sugar to 4 cups water). *With ascorbic acid.* Put peaches directly into sugar sirup to which has been added ¼ teaspoon ascorbic acid for each 1 to 1½ cups sirup.
Pineapples	Peel, remove core, slice or dice.	Sirup: Cover with 60 or 70% syrup.
Plums and prunes	Sort, wash, halve, and pit.	Pack in 1 part by weight of sugar to 3 to 5 parts by weight of fruit (1 cup sugar to 4½ to 10 cups fruit); or in sirup to cover (3 to 5 cups sugar to 4 cups water, with ¼ teaspoon ascorbic acid added to each 1 to 1½ cups sirup).
Strawberries	Cap and sort, wash, and drain well. Leave berries whole, or slice.	Pack in 1 part by weight of sugar to 3 or 4 parts by weight of fruit (1 cup sugar to 5 to 8 cups fruit). Pack tightly so juice covers berries.

Head space:	*Packing fruit in dry sugar:*
In carton or bag, leave ½ inch head space if packed without liquid. Leave 1 inch head space if packed with sirup, or for purees or crushed fruits. In glass jars or tin cans leave 1½ inches head space.	When packing fruits in dry sugar, be sure to mix thoroughly until all sugar is dissolved and sufficient sirup is formed to cover the fruit when packed. If necessary, press fruit down in package until sirup covers the fruit.

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[1] Anonymous. Home freezing of fruits and vegetables. U. S. Dept. of Agr. Leaflets AIS-48. May, 1946.

If electric power is temporarily disrupted, leave the locker door shut. Food in a loaded cabinet will usually stay frozen for two days, even in summer; if the cabinet is half-loaded, it may stay frozen for a day. The food can be kept frozen somewhat longer by covering the cabinet with a heavy woolen blanket. If power failure will last for more than a half day, place dry ice in each compartment (50 pounds per 20 cubic foot capacity), or quickly transfer fruits to commercial frozen-food lockers. If the fruits should once thaw, they can be cooked and canned, but not refrozen.

Thawing frozen foods. Frozen fruits are best when thawed slowly (six to eight hours) on a shelf of the household refrigerator. Keep the fruits wrapped while thawing. Fruit can be thawed in about three hours by placing it on the kitchen table. If placed before an electric fan, it will thaw in about one hour at room temperature. If the package is water tight, it may be placed under running cold water and thawed in about 40 minutes, or it can be thawed in 20 minutes by placing it under lukewarm water. Fruit packed with dry sugar thaws faster than fruit packed with sirup. According to E. H. Weigand of Oregon State College, a one-pound package can be thawed in two minutes by what is known as "electronic defrosting" with special equipment. Such equipment may be useful in restaurants where frozen desserts can be served quickly on request.

Berries are best for dessert when served while they still contain a few ice crystals. Although texture of peaches or similar fruits is better when they are still a little icy, flavor is improved by more complete thawing. Frozen peaches can be used in salads if they are dipped (frozen or thawed) in citrus fruit juice to add tartness and retard browning.

Fruit should be left in the sealed container while thawing and turned several times to keep it coated with sirup and prevent darkening.

Frozen fruit that has lost its fresh quality may still be used in recipes for cooked desserts.

Review Questions

1. Of what particular value is the frozen-pack method of preservation in large fruit-producing centers?
2. What are the advantages of freezing preservation over canning?
3. Briefly describe the frozen locker plants and their value to the public.
4. At about what temperatures are fruits frozen and at what temperature are they stored?
5. What are the factors influencing power consumption by freezing units?
6. What are the qualifications of a good wrapper or package for frozen fruits?
7. What fruits give the best frozen products; which fruits are not so well suited to freezing?
8. How important is variety in freezing of fruits?
9. What is the purpose of sugar-sirup or dry sugar in the frozen pack?
10. At what stage of maturity of fruits can the best frozen products be obtained? Are there exceptions?
11. What precautions can be taken if the electric power fails?

Suggested Collateral Readings

Anonymous. Home freezing of fruits and vegetables. U. S. Dept. of Agr. AIS-48. May, 1946.

Bedford, C. L. et al. Locker and home freezing of farm products. Wash. Agr. Exp. Sta. Pop. Bull. 180. 1945.
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Mann, L. B. Refrigerated food lockers—a new co-operative service. U. S. Dept. of Agr. Farm Credit Admin. Cir. No. C-107. (Revised) 1940.
Masterman, Nancy K. and Frank A. Lee. The home freezing of farm products. New York Agr. Exp. Sta. (Cornell) Bull. 611. (Revised) 1946.
Tressler, D. K. and C. W. Du Bois. Freezing and storage of foods in freezing cabinets and locker plants. N. Y. (Geneva) State Agr. Exp. Sta. Bull. 690. 1940.
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CHAPTER XX

Grape Growing

Grapes are popular in home gardens in every state of the Union. They are grown commercially in 37 of the 48 states. The industry is separated into three general regions[1] over the country according to type of grape grown: (1) regions with European-type grapes (*Vitis vinifera*), including mainly California, Arizona, and lower Texas; (2) regions with native American-type varieties (*V. labrusca,* or, its hybrids with *V. vinifera*), consisting of an area east of the Rocky Mountains and north of the Gulf states; and (3) regions with Muscadine grapes (*V. rotundifolia*), including the South Atlantic and Gulf states.

The *vinifera* grape, largely grown in California, comprises over 90 per cent of the grapes produced in the United States. This grape is exemplified by the Tokay variety commonly seen on the fresh-fruit markets in the East. *Vinifera* grapes are characterized by a relatively thick skin that adheres to a firm pulp which is sweet throughout. *Vinifera* varieties require a mild climate, such as found in California. Certain varieties are used principally for raisins, others for wine or for table use.

The native American- or Fox-type grape, which is grown principally in the lower Great Lakes regions of the United States and Canada, is the second-most important grape, commercially. Concord is the leading and typical variety. It has a relatively thin skin that adheres loosely to the pulp; the pulp is soft and relatively acid near the seeds. The American grapes require a temperate climate such as found near the Great Lakes.

The Muscadine grapes are exemplified by the Scuppernong variety which is long lived, remarkably disease resistant, and vigorous in vine. The bunches are relatively small and the berries have a strong musky odor, large seeds, ripen unevenly, and tend to shatter from the bunches when ripe.[1] The fruit is adapted to home use, wine making, and culinary purposes, but not to distant marketing as a dessert grape.

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[1] These have been further divided by Magoon and Snyder into 9 regions according to climate and variety.

Over two-thirds of the 299,180,682 (1945 census) grapevines in the United States are located in California (Figure 239). California is responsible for over 90 per cent of grape production in the United States and in some years, such as 1945, it may produce as much as 95 per cent of the total production. The relative importance of California in grape production in the United States is shown in Figure 240. The 1937–46 average annual grape production in tons by the five leading states was California, 2,505,000; New York, 55,360; Michigan, 33,820; Ohio, 17,190; and Pennsylvania, 16,330. In Figure 241, it is apparent that over half of the *vinifera* grapes grown in California are made into raisins, whereas the other portion is divided equally between wine and table varieties. The gradual increase in grape production in the United States from 1909 to 1944 was largely due to an increase in raisin varieties in California. Table-grape varieties showed only a slight increase in production. Total production by states other than California remained approximately the same during the 35-year period.

Most emphasis in this chapter will be placed on the growing of the native American-type *V. labrusca* grapes, inasmuch as they are the most widely grown in the United States. The *V. vinifera* and rotundafolia grapes will be discussed only in so far as their management differs from that of *V. labrusca.*

THE VINEYARD LOCATION

The three natural factors which largely govern where a vineyard can be properly located are climate, site, and soil.

Climate. Grape varieties have rather exact requirements with respect to total and mean temperatures of the growing season. Also, the number of days required for proper maturity of the wood and fruit varies with the variety. Most of the *V. labrusca* varieties require more than 160 days from the last frost in spring until the first frost in autumn. Largest production is located along the shores of the Great Lakes because of the tempering effect of the large bodies of water and the lengthening of the growing season. This region is especially adapted to such long-season varieties as Catawba. Concord requires fewer days than Catawba for maturity and will generally succeed in areas where the average length of the growing season is about 170 days; it is of doubtful success in regions of 157 days and generally unsuccessful at 145 days. Commercial plantings of grapes should be confined to favorable sites in recognized and established areas in the state (See Magoon and Snyder for detailed recommendations).

Site. In the East, there are many small vineyards outside the commercial

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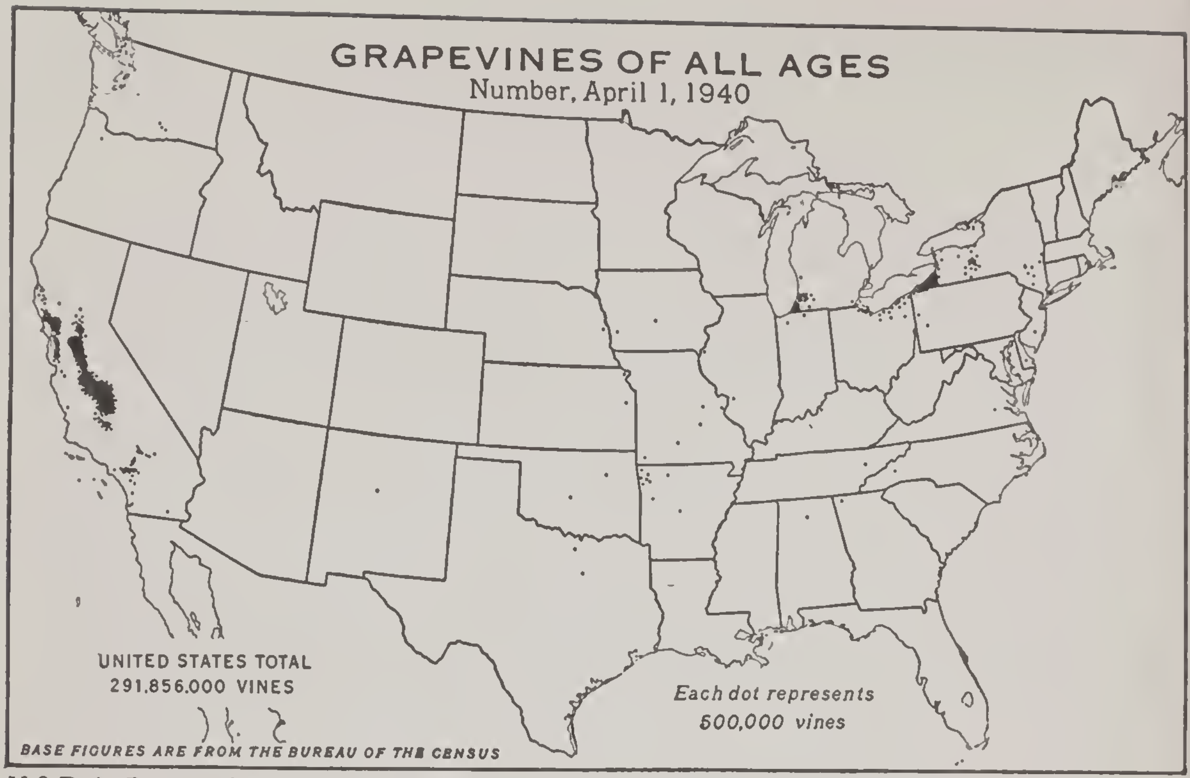
[1] A few varieties are now available which do not shatter from the bunch.



U.S.D.A. Bureau of Agricultural Economics

Figure 239. California has over 233 million grapevines, or about 70 per cent of the United States total. New York ranks second with about 25 million vines. Grapes from eastern areas are mainly consumed fresh or made into juice. In California, grapes used for raisins are grown around Fresno, wine grapes come mainly from San Francisco Bay area, and table grapes come from vineyards in the Sacramento and San Joaquin valleys and from the southern section of the state.

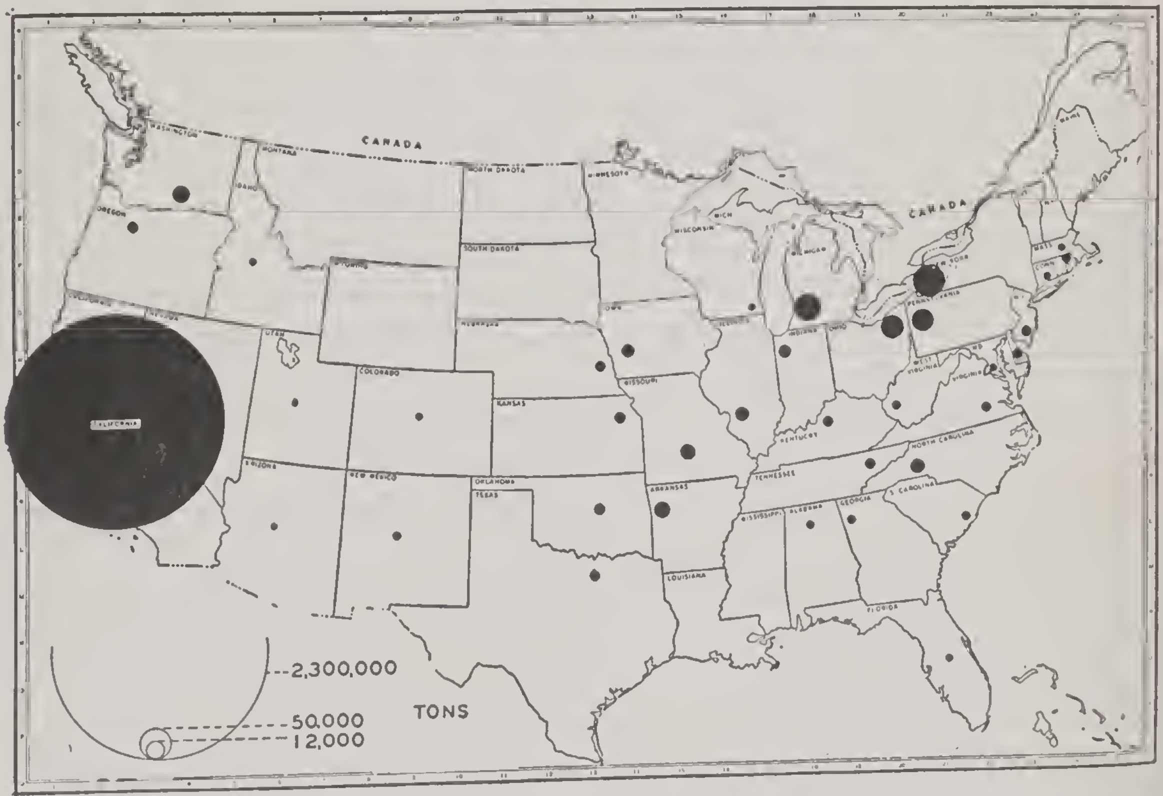
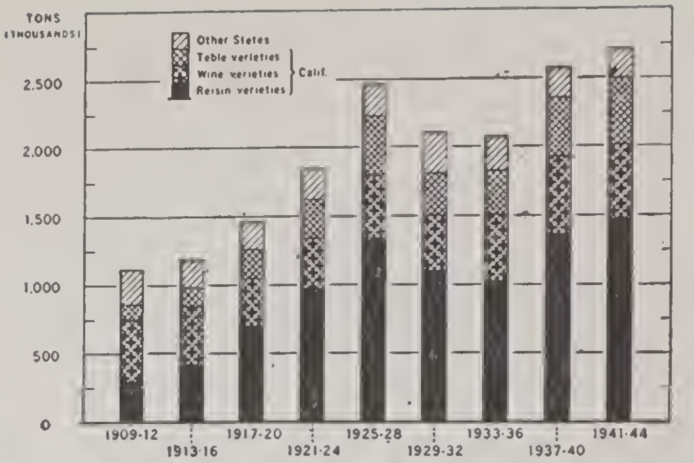


Figure 240. California produces 90 to 95 per cent of the grapes in the United States, consisting almost entirely of the European-type grape (*Vitus vinifera*). The American-type grape (*V. Labrusca*) or hybrids of it with *V. vinifera* are grown mainly in the central and northeastern states, while the Muscadine (*V. ratundafolia*) is grown in the Gulf and South Atlantic states. New York, Michigan, Ohio, and Pennsylvania rank in order of production after California.



U.S.D.A. Bureau of Agricultural Economics

Figure 241. Grape production in the United States by four-year averages is shown from 1909 to 1944. Gradual increase in production is attributed largely to an increase in raisin varieties in California. Grape production in states other than California has remained approximately the same during the 35-year period.

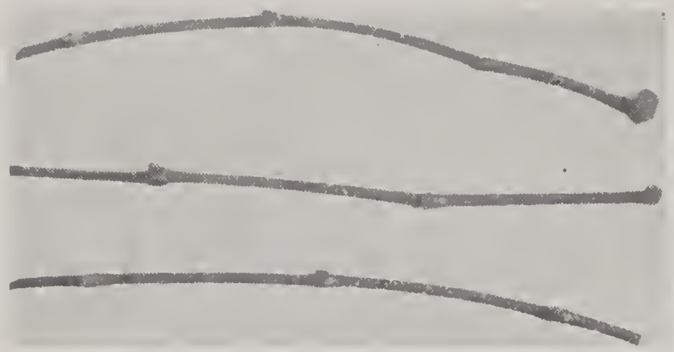
regions which supply grapes for local markets and for home use. If the climate for a particular region is doubtful for grapes, special attention should be given to selection of a frost-free site and the use of adapted varieties. The vineyard should be somewhat above the surrounding country. The ground may be almost level provided there is opportunity for cold air to drain on one or two sides. Air drainage through and away from the vineyard not only reduces the danger from late-spring and early-fall frosts, but also is highly important in the control of many diseases of grapes. In the southern extensions of the industry, the tempering effect of large bodies of water is not such an important factor, but air drainage is of primary consideration. There appears to be no advantage in having the land slope in a particular direction. Steep land without bench terracing is undesirable due to the soil erosion factor.

Soil. The best vineyards in the East are growing on moderately fertile, well-drained, sandy, or gravelly loam soil (four to six feet rooting area) which contains a good supply of organic matter. Grapes will grow on a wide variety of soils both in the East and West, including the heavy clays provided they contain plenty of organic matter and are *well drained.* In general, the lighter sandy type of soils promote earlier ripening and higher sugar content of the grapes than do heavy soils.

SELECTION OF VARIETIES

Only those varieties should be planted in a commercial vineyard that are adapted to the region and have proven their value over many varied seasons. There are a number of new varieties being promoted which should be tried first on a small scale before considering them for commercial use. In the Great Lakes regions, there is a trend toward planting varieties which are suited for wine production, such as Catawba, Delaware, and Niagara. Although there is considerable wine made from the Concord variety in this region, Concord is better adapted to use in unfermented grape juice, processed grape products, and in a limited way for the table grape trade. Concord should be used less in the future for wine.

American-type grapes which are generally recommended for commercial plantings in the Great Lakes regions are in the order of ripening: Fredonia



F. H. Beach, Ohio State University Agr. Ext. Serv.

Figure 242. Grape cuttings for propagating new vines in the nursery. (Top) Mallet-type cutting is frequently used, consisting of current season cane with small section of 2-year wood at base. (Middle) Type of cane most commonly used. (Bottom) Cuts on this cane are improperly made.

(blue), Niagara (white), Delaware (red), Concord (blue), and Catawba (red). *Fredonia* has shown a rapid increase in popularity in recent years because it ripens about three weeks earlier than Concord, the berries are larger, the bunches more compact and the juice is a deeper red. The vines are hardy, very vigorous, and more productive than Concord. One of the disadvantages, however, is the fact that the berries are apt to shatter from the bunch unless marketed within four or five days after picking. *Niagara* has large compact bunches of high-quality yellow-green berries. The vigorous vines are adapted to a wide variety of soils. Since white grapes are limited in market demand, they should be planted in amounts to suit local requirements. Two disadvantages of Niagara are tenderness to winter cold and the fruit and leaves are somewhat more susceptible to fungus diseases than those of Concord. *Delaware* is a standard midseason variety, hardy, one of the highest-quality table grapes, ships and stores well, and serves equally well as a juice, wine, and table grape. Bunches, berries, and vines are relatively small. Delaware is a slow-growing grape which should be planted closer than most varieties (about eight feet) and requires good soil management and fertilization with relatively close pruning. *Concord* is the standard blue grape in the East. It succeeds under a wide variety of soil and climatic conditions. The vine is vigorous, hardy, highly productive, and fairly resistant to attacks of insects and diseases. The fruit ripens evenly, stands reasonable shipment and storage, and is highly prized for juice, jelly, and table use. It is widely used in dry table wines. Probably over 75 per cent of the varieties grown in the Great Lakes regions consist of Concord, but there is a trend toward replacing Concord with varieties better suited for a particular demand. *Catawba* requires a longer growing season than Concord. Berries and bunches are of medium size, ship well, and can be stored until almost midwinter under proper conditions; the vines are fairly productive and hardy, medium in vigor, but foliage and fruit are relatively susceptible to fungus diseases. It should be pruned closer than Concord. Although Catawba is a fine table grape when picked fully ripe, its important outlet is for a high-grade white wine used as a base for champagne. It is also excellent for unfermented grape juice.

Among the American-type varieties recommended for home and trial planting in the East are Portland, Ontario, Worden, Brocton, Captivator, Golden Muscat, and Sheridan.

PROPAGATION OF GRAPES

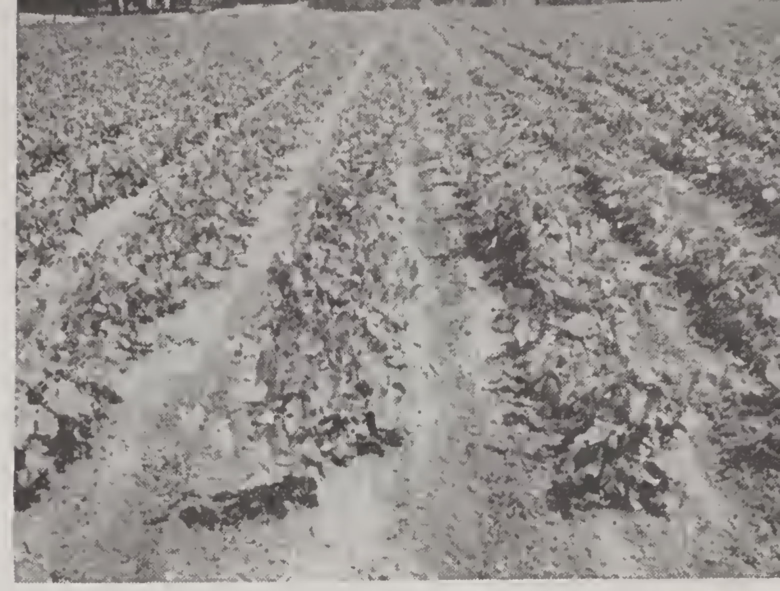


Figure 243. A nursery of grape cuttings in July in northern Ohio. These will be ready for sale as 1-year plants the following spring.

Cuttings. Grapes are commonly propagated by cuttings. The process is simple, and if time permits it can be done by the grower as well as the nurseryman. Cuttings are made in early winter from dormant canes of last year's growth. The canes should be about one-quarter-inch diameter, well matured, and rather short-jointed. As shown in Figure 242, each cutting has three buds with the lower cut made just below the lowest bud and the upper cut an inch or two above the third bud. Cuttings should average about eight to ten inches in length. The cuttings are tied in bundles of 25, using jute or binder twine, and buried base-up in a trench located on a well-drained spot. Cover the buds with about three inches of soil. An additional covering of six inches of manure or straw will help protect them during cold weather and aid in callusing the butt ends while the tops remain dormant.

Prepare a fine friable bed for planting the cuttings. The best plants are grown on well-drained sandy or gravelly soils which encourage development of an extensive root system. Remove the bundles in early spring. Separate and line out the cuttings about six inches apart in rows three feet apart. (Figure 243). Thoroughly firm each cutting in the soil and plant with the top bud just above the soil surface. During the first growing season, shallow cultivation and hand hoeing should be done often enough to keep the weeds under control. A 50 to 60 per cent stand is the average experience. The following spring the plants can be dug and set to the vineyard. The larger plants are the most satisfactory.

Layering. The principal value of layering is to replace missing vines in the vineyard. Plants started by layering in an established vineyard usually grow faster than one-year plants secured from the nursery. As shown in Figure 244, a vigorous cane from the nearest vine is bent to the ground and placed in a furrow three inches deep at the place where the new vine is desired. The cane is covered except for three buds left exposed beyond the covered area. The best single shoot developing from the three buds is trained to form the trunk of the new vine. This new trunk is left attached to the mother plant for two to three years or until it is thoroughly established before cutting the connection.

Grafting. Many varieties of American grapes, such as Delaware and Catawba, have benefited by more growth and production when grafted on vigorous congenial rootstocks. Evidence in the East, however, is insufficient to recommend the practice widely on a commercial scale. Also, the supply

F. H. Beach, Ohio State University Agr. Ext. Serv.

Figure 244. A simple and effective method for replacing missing vines is to layer a vigorous cane from the neighboring vine. Stake serves to locate layered cane during cultivation.

of grafted vines in the East is limited because few nurserymen produce them. *Riparia Gloire* has shown promise as a rootstock for Delaware and Concord. Clinton has proved satisfactory for Catawba and Niagara. Cuttings of one-year-old rooted plants may be whip-grafted to desirable cions, callused, and set to the field. Established vines can be cleft-grafted in early spring. In place of grafting wax, however, the soil is mounded around and over the cleft graft to provide protection and allow for drainage. Detailed information on grafting and budding procedure for grapes can be secured from accompanying references.

PLANTING THE VINEYARD

Nursery stock. One-year-old No. 1 grape plants with well-developed root systems are most satisfactory for planting (Figure 245). Two-year plants may be unsatisfactory for several reasons. Most eastern grape growers secure their planting stocks from near-by reputable nurserymen rather than to attempt to grow their own plants and cuttings.

Plant the cuttings as soon after arrival as possible. Early spring planting is recommended in the northern states. If the plants arrive before convenient planting time, they should be heeled-in immediately on a well-drained site, preferably near the north side of a building. Prepare a furrow deep enough to accommodate the roots, untie the bundles, separate the plants, and distribute them along the furrow. Pack the soil thoroughly around the roots so there are no air spaces. Cover most of the tops with soil, then cover with a wet burlap or moist soil to keep them dormant in case the weather suddenly turns warm.

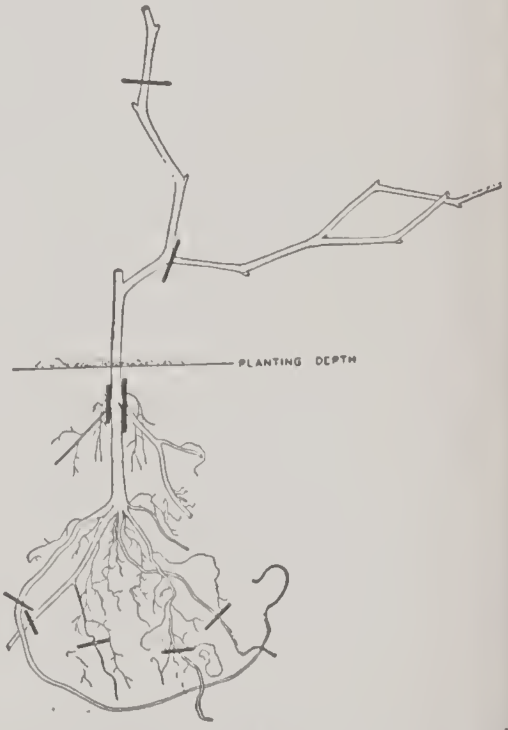
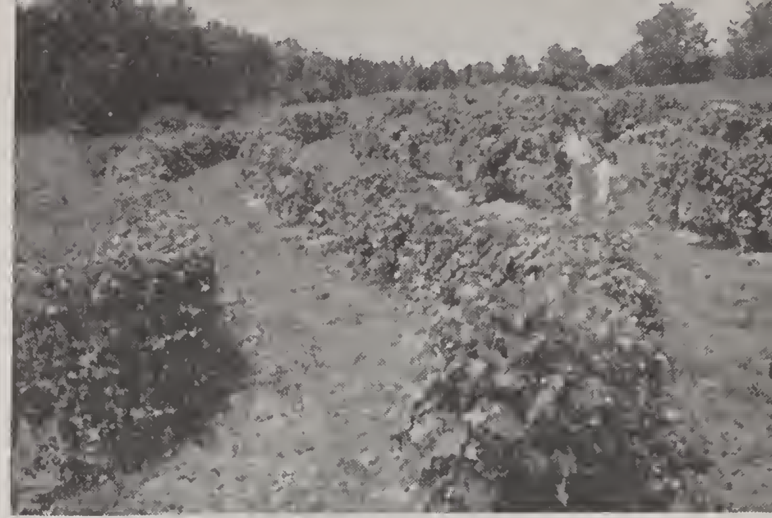


Figure 245. Before planting a rooted grape cutting, the tops and roots are pruned as indicated by black marks. The planting depth is shown.

Preparation of soil for planting. Plow and harrow the soil for early spring plantings. Sod land to be used for a vineyard should be planted to a cultivated crop for at least a year before setting the vines. Contour planting is suggested to avoid soil erosion on sloping land (Figure 246). Grape rows must be cultivated in a commercial vineyard, so every precaution must be taken to avoid soil erosion losses. Where available, an application of six to eight tons per acre of barnyard manure before plowing is recommended to improve growth of both vines and cover crop.



J. T. Bregger, U.S. Soil Conservation Service

Figure 246. On rolling land there is opportunity for surfoce erosion in spite of good cultural monogement. If the vineyord is plonted on the contour, erosion is reduced to a minimum, and considerobly more roinfall is retoined in the vineyord.

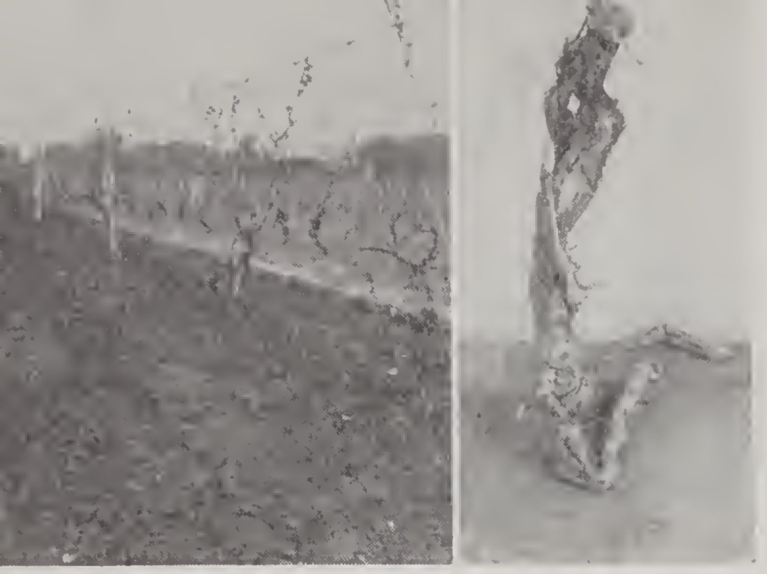
Planting. Rows can be lined out with a three-foot guide stick at each end and as many stakes in between as are needed on long rows. A straight furrow is then plowed out along row lines. After row lines have been plowed out, a heavy chain or other suitable marker can be dragged at right angles across the furrows to mark the points where plants are to be set. Planting distances vary with the variety and type of soil. Vigorous varieties such as Niagara, Concord, Fredonia, and Sheridan on good soils should have the rows spaced ten feet apart with the plants nine to ten feet apart in the row. Less vigorous varieties as Catawba and Delaware may be set seven to eight feet apart in the row. If plants are set ten by ten feet, 434 plants will be required per acre; if ten by nine feet, 484 plants; and if ten by eight feet, 544 plants.

Rows spaced ten feet apart are desirable to facilitate spraying and cultivating and for convenient hauling at harvest. In large commercial vineyards, it is desirable to provide cross alleyways to facilitate the movement of machinery. Alleyways should be spaced at intervals of about 300 to 400 feet.

Before setting the plants, prune the roots only enough to cut away broken portions and ragged ends, as shown in Figure 245. Place and arrange roots well in hole, firming the soil around and over them. The top is cut back to two buds on the best single cane after planting.

SOIL MANAGEMENT

Cultivation. Growth and yields are improved by frequent shallow cultivation beginning as early in spring as soil can be worked and continuing through early summer. If the season is dry and the crop large, cultivation should be prolonged to keep down weeds and conserve moisture. If moisture is plentiful, discontinue cultivation to induce early maturing of wood and fruit. It is important that the wood enter the winter well-ripened to avoid freezing injury and a consequent crop reduction the following year.



(Left) George W. Still, U.S.D.A. Grape Insect Laboratory, Sandusky, Ohio. (Right) I. W. Wander, Florida Agr. Exp. Sta.

Figure 247. (Left) This soil near Lake Erie was turned toward the vines in spring to help control grape berry-moth by burying the cocoons. (Right) Base of dead grapevine due to severe root pruning by close deep cultivation (view looking down the row, Ohio).

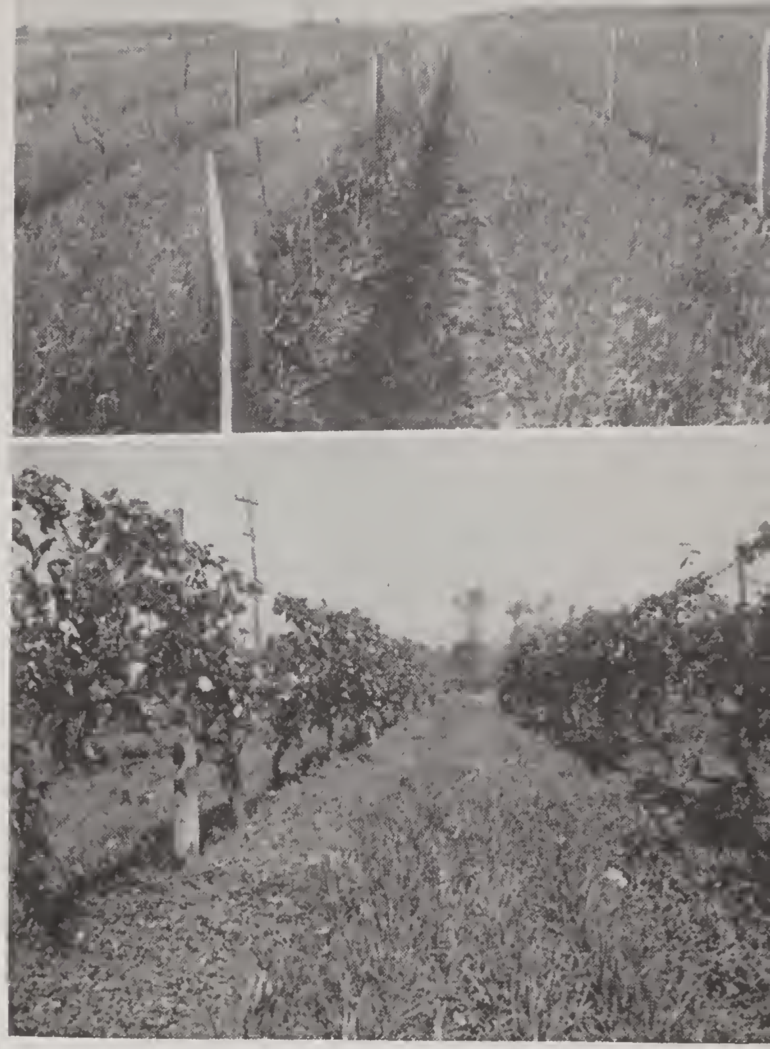
If a winter cover of rye has been used, it should be disked in while rye is leafy and before it has jointed. Shallow cultivation not deeper than three to four inches, especially near the vines, is highly important; deep cultivation results in excessive root pruning and death of vines, as shown in Figure 247. Continue cultivation with a disk or spring-tooth harrow to kill weeds, to prevent soil from baking, and to properly level the vineyard until time for seeding the cover crop. On gravelly or sandy soils where drainage is good, the vineyard can be left level overwinter. However, on heavier loams and clay where surface drainage is slow, one or more rounds should be made with a plow or grape hoe, or both in late fall (Figure 248), throwing the soil in a ridge under the wires. The ridge should be high enough to provide surface drainage away from the grape row during the winter and prevent heaving damage to the vines. Where the grape-berry worm is a problem, as in the Great Lakes regions, soil thrown toward the vines in fall or early spring should be left under the trellis undisturbed until about a week to ten days after grapes bloom. This cover of two or more inches of fine soil about 18 inches in width under the trellis (Figures 247, 248) holds and kills over 80 per cent of the emerging moths.

Cover crops. Since more cultivation is practiced in vineyards than in orchards, it is highly important that soil organic matter be maintained by the growing of cover crops. Cover crops reduce soil erosion and losses from leaching of mineral nutrients during fall and winter. They also aid in properly maturing the wood in the autumn, thus reducing risk from winter injury.

Soybeans, rye or ryegrass are common cover crops in the Great Lakes region. In young vineyards, two cover crops a year are often grown. Soybeans can be planted about June 1 and disked under in late August when the vineyard is drilled immediately to a rye cover crop. When the vineyard has become established and is in full bearing, a single cover crop, such as oats or rye sown at the time of last cultivation in late July or early August and turned under the following spring, provides a cover crop which is quite satisfactory for most soil types. Another cover crop receiving considerable attention in the Great Lakes region is domestic ryegrass which can be sown earlier than rye. It makes a larger root system but less top growth in the spring than rye and, therefore, can be worked down later.

If at all possible, cover crops such as wheat, rye, and ryegrass should be drilled in order to confine the cover crop to the middles between the rows (Figure 248). To facilitate grape harvest, the growing cover crop of rye can be flattened with a roller or planker just before the grapes are harvested. Where a cover crop is desired which kills overwinter, oats or buckwheat sown in July or early August are worth considering.

Liming. Rye will grow in a relatively acid soil, but if soybeans or other legumes are desired, it may be necessary to add lime to bring the pH to around 6.5 for best growth. An over-all application of 250 to 300 pounds of a 4-10-6 or similar grade fertilizer per acre is recommended at seeding time to promote the greatest bulk of cover-crop growth. It is important to obtain an extensive root system with the cover crop to derive greatest benefits.[1]



(Top) F. H. Beach, Ohio State University Agr. Ext. Serv. (Bottom) George W. Still, U.S.D.A. Grape Insect Laboratory, Sandusky, Ohio.

Figure 248. Cover crops are important in good vineyard management. (Top) Rye cover crop early in May in northern Ohio. Note soil turned with grape hoe toward vines on both sides to cover overwintering berry-moth cocoons. Soil will be thrown back about two weeks after bloom. Rye cover is almost ready to be disked. (Bottom) A drilled wheat cover crop photographed in September in northern Ohio.

MANURE AND FERTILIZERS

Manure. Tests performed by agricultural experiment stations in the East and confirmed by the experience of many growers have shown that manure is probably the best all-round fertilizer for grapes. Applied during the winter or very early spring at the rate of six to eight tons per acre, manure has often increased yield by about 30 per cent. However, due to the fact that manure is limited for commercial grape growing, growers must rely chiefly on commercial fertilizers and soil-improving cover crops.

Nitrogen fertilizers. Grapes in general have not responded as readily to nitrogen fertilizer applications as other fruit crops, except perhaps on exhausted soils. This may be due in part to the heavy annual pruning given the grapevine. However, when growth becomes unsatisfactory to support the proper number of buds per vine after pruning, nitrogen fertilizer appli-

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[1] Cover crops, seeding dates, and rate of seeding per acre are given on page 102.

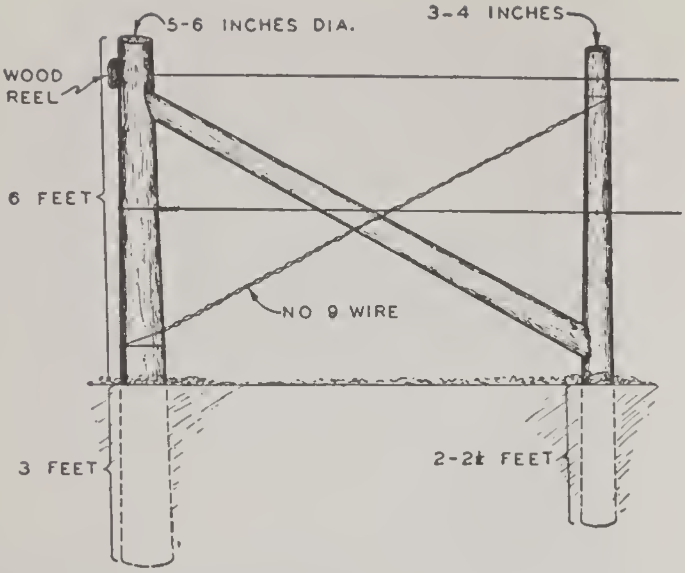

Figure 249. Trellis and posts are particularly strong when braced as shown. Life of posts is increased by soaking lower ends in creosote before setting. Wood reel may be used with ratchet for tightening wire.

cations are usually beneficial. Nitrogen shows the most immediate and greatest effect on vines on sandy or gravelly soils. On the heavier soils, it may require two or three years before a response is indicated from nitrogen. Applications can be made in late fall or early spring. For vines of moderate vigor, use 300 pounds per acre of nitrate of soda, or 250 pounds of sulfate of ammonia or Cyanamid, or about 150 pounds of ammonium nitrate. On the basis of a single vine, this would be about one-half pound of ammonium sulfate for vines of moderate vigor. For weak vines, one-third pound per vine is suggested. Broadcast the fertilizer in strips on either side of the grape row if nitrogen is used alone, or, if a complete fertilizer and lime (for legumes) are applied together to benefit the cover crop, they should be applied evenly over the middles of the rows. Cyanamid is preferred as a fall application. Other nitrogen fertilizers are applied just before growth starts in spring. Continued use of sulfate of ammonia may increase soil acidity and necessitate occasional applications of agricultural limestone to keep the pH around 6.0. Magnesium and minor elements should be considered on sandy soils.

THE TRELLIS

Most commercial grape growers do not expect much production until the third growing season. The plants should be staked during the first growing season after planting, and the strongest shoot for each vine trained to the stake. The trellis should be in place at the beginning of the second season of growth, if possible. While the trellis is an important item in the expense of establishing a vineyard, a strong durable support system set at the start will be cheaper in the long run.

Posts. Posts should be set from 24 to 30 feet apart with three vines between the posts. Exact distance between the posts will depend upon whether the planting distance between the vines in the row is eight, nine, or ten feet. Posts should consist of durable wood, such as white oak, locust, or cedar, preferably creosote-treated to prolong life. There is a growing tendency to use metal posts, and although the initial cost of these posts is higher than wood, they are more durable, relatively free from frost heaving, drive and handle better in the ground, and look neater. End wood posts should be heavier and longer than line posts with a top diameter of five to eight inches, and a length of about nine feet to permit setting three feet in the soil, as shown in Figure 249. Reinforced concrete is sometimes used for end posts. Line posts can be somewhat lighter, or at least three inches in top diameter and seven to eight feet long to permit driving two feet in the ground where the Kniffin system of training is used. For the Fan system of training, described later, posts can be somewhat shorter. Six- to seven-foot posts are often used, driven about 18 inches in the ground. If the wooden posts are sharpened, they can be driven into the ground with a heavy 12- to 14-pound maul while the operator stands on a wagon or truck bed.

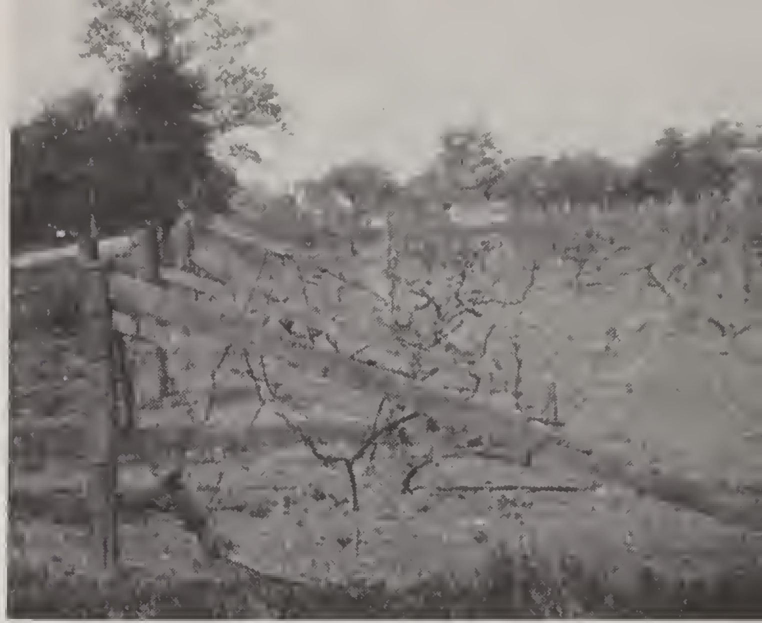

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Figure 250. A satisfactory method for bracing end posts used in northern Ohio.

End posts require sturdy bracing. A satisfactory bracing system is shown in Figure 250 where a four by four-inch brace is run from near the top of the end post obliquely toward the ground and fitted against a short post set about eight feet back in the row from the end post. A second method of bracing is to carry a brace wire from the top of the endpost to a large rock or log ("dead-man") buried about two feet in the ground beyond the end post. Objection to this bracing method is that the brace wire is frequently caught by cultivating tools. A third method is shown in Figure 249, in which a second post is set six to eight feet back in the row from the end post. A guy wire is secured from the top of the second post to the base of the end post and a two- by four-inch oak brace is placed diagonally between these two posts, notched in place near the top of the end post and at the base of the second post. This type of brace is particularly solid.

Wires. If the Kniffin system of training is used (Figure 253), a two-wire trellis is satisfactory with the upper wire consisting preferably of the heavier No. 9 gauge wire and the lower wire of No. 10 gauge. For the Fan system of training (Figure 256), two or three wires of No. 10 or 11 gauge may be used. A durable galvanized wire is preferred. The amount of wire needed can be calculated from the table below.

Gauge of Wire	*Feet per Pound*
9	17.05
10	20.57
11	25.82

For the Kniffin system, the upper wire is located from five and one-half to six feet from the ground and the lower wire is about three feet from the ground. With the Fan system, the lower wire is usually about 24 inches

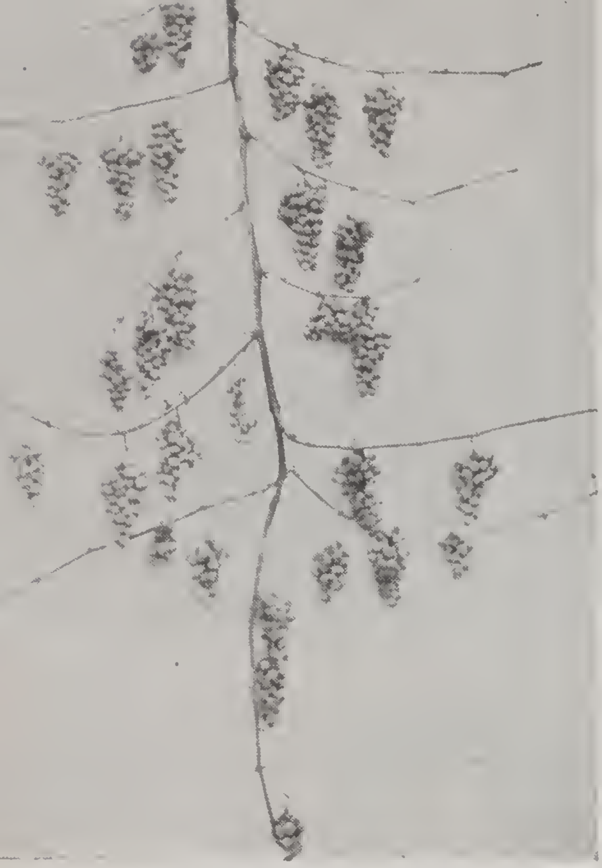

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Figure 251. A defoliated fruiting Catawba cane showing location of best clusters and where most fruit is produced. On the average, the fifth, sixth, and seventh buds from the base of main cane develop most productive shoots.

from the ground, which is a convenient height to tie the Y-arms of the trunk. The two other wires above are spaced from 18 to 24 inches apart. If two wires are used in the Fan system, they are strung at heights of about 30 inches and 5 feet, respectively, from the ground. Long staples are used for attaching the wires into the line posts. The wire should be loose in the staples so that it can be tightened at the end posts as needed. Wires are more secure if placed on the windward side of the posts, or on the upper side in hillside vineyards. Iron wires contract during cold weather and should be loosened in the fall to prevent undue strain on the end posts. In spring after pruning is completed and before the canes are tied, the posts should be driven down where necessary and the wires tightened, using a common wire stretcher. Each wire should be fastened securely to the end posts; a good method is shown in Figure 249. A ratchet-type of tightener is often used.

Another method for tightening wires is to cut the wire midway between end posts and use a wire stretcher, then splice the wire after it is drawn taut.

Trellis for contour rows. On the sharper curves in the contour planting system, extra posts should be used, some of which are set deeper or set in concrete to help absorb the extra strain encountered at these points. No bracing other than at the end posts is needed. If terraces are used with contour planting, the trellises should be established on the ridges. For establishing contour lines and terraces, see Chapter II.

PRUNING AND TRAINING

Growth and fruiting habits of vines. Grape clusters are borne laterally near the base of leafy shoots which arise from the buds on one-year-old wood or canes, as shown in Figure 251. Shoots which arise from wood older than one year are usually unproductive or produce inferior grapes. For good grape production, it is important, therefore, that the vines be pruned annually so that an adequate amount of conveniently placed one-year-old wood is available from year to year near the trunk of the vine. Average yield for a Concord vine grown under good conditions is about 15 pounds. A bunch of grapes usually weighs from one-quarter to one-half-pound. Thus, from 30 to 60 bunches are needed to produce the 15 pounds of fruit. If each fruit-bearing shoot produces from one to three bunches, the vine after pruning can produce 15 pounds easily from 30 buds or less.

Relatively heavy annual pruning is necessary because a vine before pruning contains an excessive number of buds. Heavy pruning is also necessary to prevent an undesirable amount of old wood from accumulating and to select a proper number and length of desirable fruiting canes near the trunk of the vine from year to year.

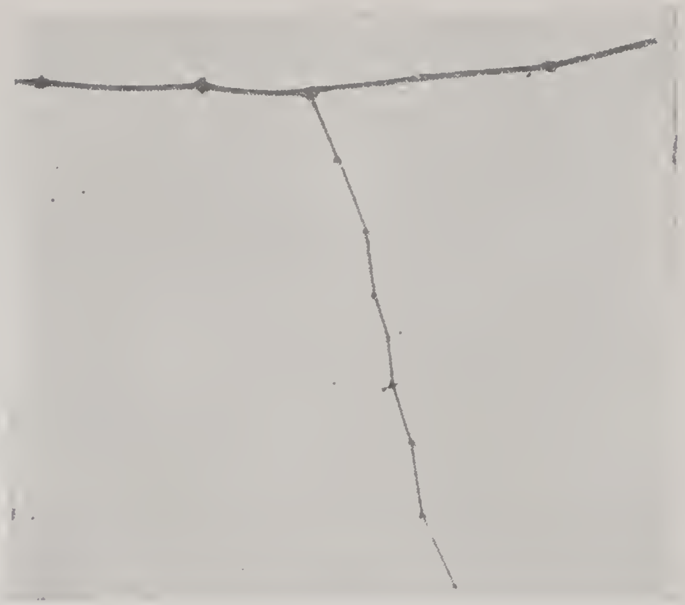
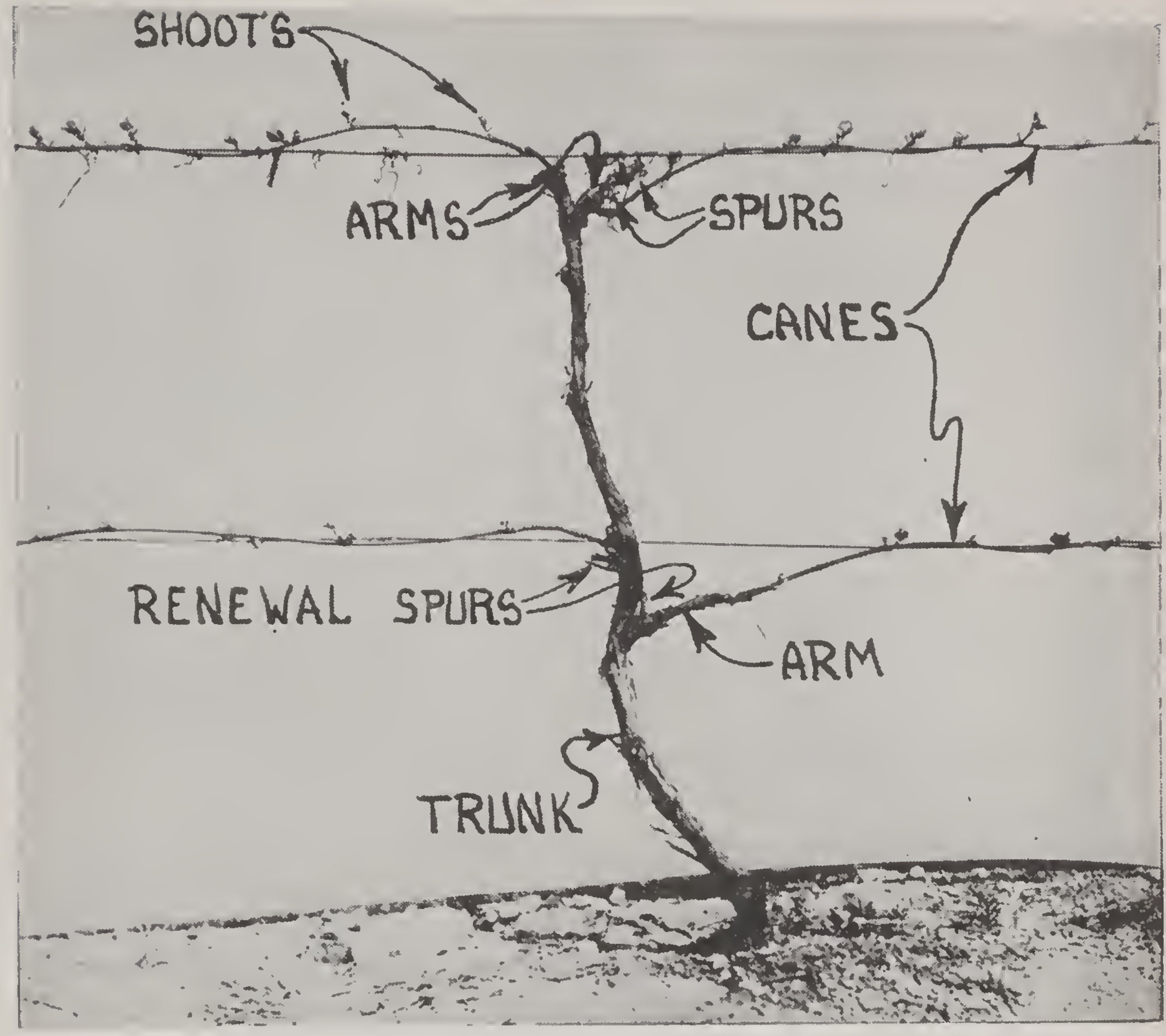

F. H. Beach, Ohio State University Agr. Ext. Serv.

Figure 252. An overvigorous unproductive bull cane is shown above. Medium-size lateral which developed the same season may be retained for fruiting wood, if fruiting wood is scarce.

Parts of vine defined. Pruning recommendations can be better understood if the reader is familiar with the common terms for the different parts of the vine.

Trunk: The main unbranched stem of the vine. *Arm:* Short branch of old wood extending from the trunk. *Old wood:* Parts of the vine older than one year. *Shoot:* Leafy growth developing from a bud which may support blossoms and later fruit. During the growing season, such growths are called shoots; after the leaves have dropped, they are called canes. *Canes:* The dormant shoots which have become woody and which carry buds or eyes. *Bull canes:* Excessively large canes with long internodes; buds are usually small and relatively unproductive. Laterals from bull canes, however, may be used for fruiting canes (Figure 252). *Lateral:* The side branch of a shoot or cane. *Spur or renewal spur:* A cane which has been cut back to a short stub carrying one or two buds and placed to develop a shoot to be used as a fruiting cane the following year (Figure 253). *Node:* The joint on a shoot or cane where leaves, tendrils, or buds are located. *Internode:* The portion of the shoot or cane between the nodes. *Eye:* The compound bud at each node on the cane. *Primary bud:* Largest and most important bud of the eye at a node. *Secondary buds:* The smallest buds at a node which often develop into shoots when the primary buds fail due to frost injury. Such a shoot is less productive than a shoot from a primary bud. *Sucker:* A shoot which arises from below the ground. *Water sprout:* A shoot which arises along the trunk or arm.

Season for pruning. In the northern states the best time to prune is after danger from heavy freezes and until the buds begin to swell. In Ohio and neighboring regions, this is from the middle of February until about the first of April. Canes will "bleed" sap from cut ends if pruned after the sap



W. P. Judkins, Ohio State University

Figure 253. The 4-cane single-trunk Kniffin system is well adopted to vigorous varieties of grapes such os Concord, Niagara, ond Fredonia. The vine is pruned to 4 canes, totaling about 40 buds. A renewal spur with two buds is left near the bose of eoch cane in order to renew the fruiting wood next year.

starts to run and while the buds are swelling. While bleeding may annoy the worker, it is not serious. Pruning should be completed as early as possible, preferably by about the middle of March. Vines should never go without annual pruning. Pruning is not recommended during the growing season, since grapes do not require direct sunlight to develop color. Large high-quality bunches are possible only with full development of healthy leaves. During the summer, it is necessary at two- to four-week intervals to tie back stray shoots growing on the ground or toward the row middles.

PRUNING YOUNG VINES

There are several systems of pruning grapes, including those which the shoots are allowed to droop (single or Y-trunk Kniffin with four to six canes, Umbrella, and Munson systems), and those in which the shoots are tied to upper wires during the growing season (Fan, Chantaugua, and Keuka

High renewal). Although the latter three systems are said to be specially adapted to weak-growing varieties such as Delaware, the four-cane single-trunk Kniffin system appears to have more advantages and has proven quite satisfactory for all varieties. For this reason, most emphasis will be placed on the four-cane Kniffin system as fundamentally shown in Figure 253.

First year. Immediately after planting, remove all but the strongest cane and cut it back to two buds. As shoots become woody in early summer, special attention should be given to pruning the young vines to develop a single vigorous shoot. The vines should be trained to a five-foot stake, as shown in Figure 254, to aid in developing straight trunks.

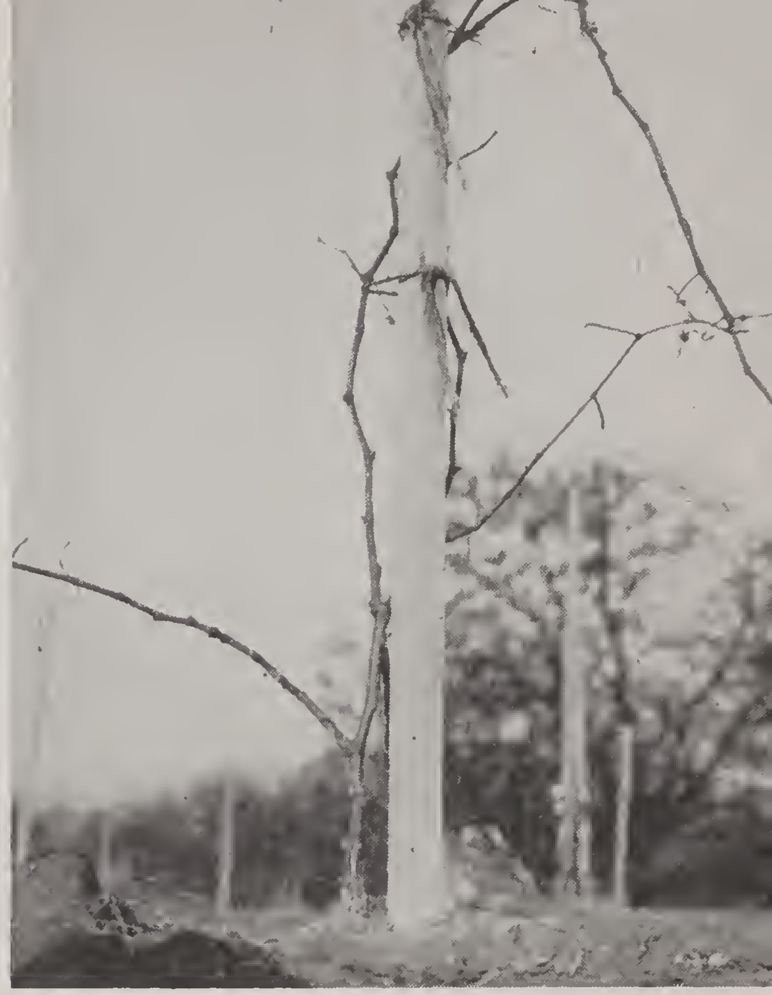


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Figure 254. Before trellis is erected a four- to six-foot stake aids in producing a straight trunk which greatly facilitates subsequent vineyard management.

Second year. Assuming that the trellis is ready at the beginning of the second year, remove all side branches on the vigorous cane and tie it to the lower wire and with an extension string anchor the tip to the top wire. If the cane reaches above the top wire, prune it about three inches above the wire. If the trellis is not ready at the beginning of the second year, it is best to stake the canes if they have not already been staked in order to develop and maintain a straight trunk. If at the beginning of the second year, the cane growth is weak or less than three feet, cut off all but the best single cane and cut this back to two buds as recommended after planting.

Third year. A vigorous vine at the beginning of the third year can carry about 25 buds after pruning. Select two of the best canes near each wire level (making four canes in all) and prune away the rest, leaving one renewal spur with two buds near the base of each selected cane, as shown in Figure 253. Cut the canes to about a six-bud length on the lower wire and a four- to five-bud length on the upper wire. The two canes at each wire level, one trained to the right and the other to the left, can be spiraled around the wire and tied loosely to it in one or two places. These canes when cut back the following year become the arms (Figure 253) from which fruiting canes are selected for each wire level in later years.

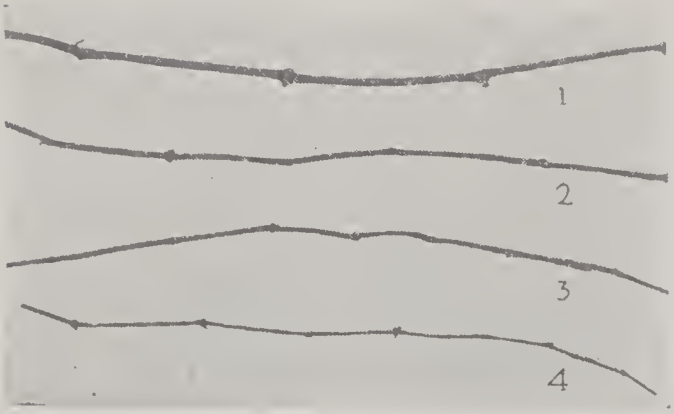

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Figure 255. Select and retain proper fruiting wood while pruning. No. *1* is too large; buds are far apart and weak and small. Nos. 2 and 3 are intermediate in size. No. 3 is particularly good; distance is relatively short between large plump buds. No. *4* is too small.

PRUNING MATURE VINES

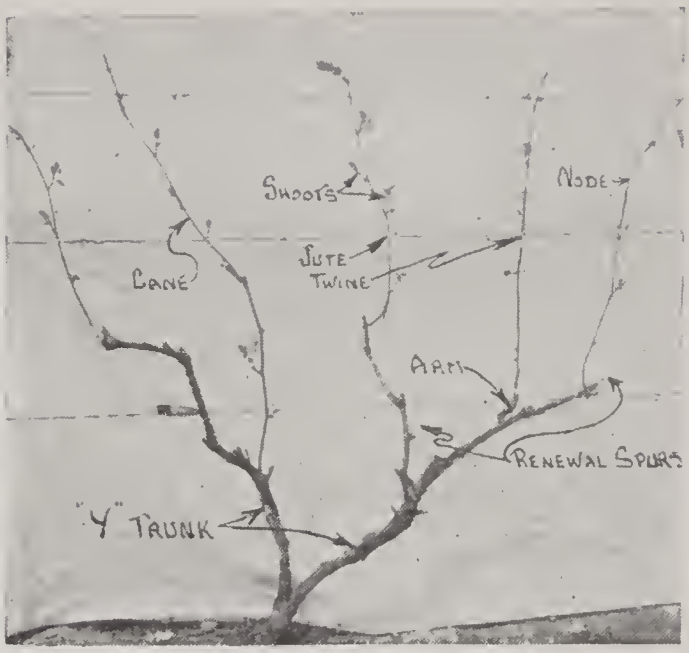
Purpose of annually pruning old vines is to train the trunk and arms so that the minimum amount of old wood supports the desirable type, length, number and distribution of canes. The renewal spurs are provided near the base of the fruiting canes to give a source of desirable new canes for fruiting the following year.

The canes selected for fruiting should be stocky, medium-sized, and carrying plump vigorous buds (Figure 255). Concord canes and varieties of similar vigor should measure one-quarter-inch in diameter between the fifth and sixth buds from the base of the cane. Canes with eight to ten buds after pruning are the most desirable length. These canes should arise as near the trunk of the vine as possible and renewal spurs should be provided near the base of each cane, as shown in Figure 253. Remove all surplus wood, leaving only fruiting canes and spurs. Then tie the fruiting canes to the trellis with jute twine or light wire, using a loose tie.

Each vine provides a different problem. In every vineyard, one will find weak and strong vines and pruning must be adapted to the age, vigor, and to the individual canes on the vine. Vigorous Concord vines in well-managed vineyards may carry 40 or more buds after pruning, whereas with weaker-growing vines and varieties, half this number of buds may result in better fruiting. Usually the fifth, sixth, and seventh buds, counting from the base of a vigorous cane (Figure 251), will develop the most productive shoots, and such canes pruned to eight and ten buds are very desirable for fruiting.

PRUNING NEGLECTED VINES

If mature vines have been neglected for a year or more, they become very rangy with too much old wood. The best fruiting wood will be found a long distance from the base of the vine. Select from four to six reasonably desirable canes for fruiting as near to the central trunk of the vine as possible. Remove all old wood beyond these canes. Remove also any additional old wood coming from near the base of the vine or the main trunk, which will not be needed in fruiting in subsequent years. After two or three years of renewal pruning, neglected vines can be brought back within bounds to a fairly manageable pattern. A special effort should be made each year to select fruiting canes closer to the central trunk of the vines. It is usually best to prune neglected vines to a pattern approaching a modification of the Fan system, as shown in Figure 256. Neglected vines should never be dehorned (cut back leaving two- to four-foot stubs near the base of the vine), since there are no canes left for fruiting and it will take a year or two to obtain satisfactory canes.



F. H. Beach, Ohio State University Agr. Ext. Serv.

Figure 256. A large percentage of the commercial grapes near Cleveland are trained by the modified-fan system. The Y-trunk and the arms remain more or less permanent while the canes are renewed each year. A renewal spur is provided for each cane on or near its respective arm.

Sometimes it is possible to select a sucker arising from the base of the trunk for training straight to the upper wire to be used as a future central trunk for the new vine. This cane is trained during the subsequent one or two years into a four-cane Kniffin system, after which the balance of the vine is cut off near the ground surface. This method is often desirable also for replacing an old crooked trunk in a commercial vineyard which may be awkward to handle and is losing vigor due to diseases or insects.

Other training systems. The *Fan* system is frequently seen along the shores of the Great Lakes in northern Ohio and western Pennsylvania and New York. It is employed chiefly for weak-growing varieties such as Catawba and Delaware, where fewer than four canes may be left after pruning. With this system, the trunk is trained into a "Y" which contains short arms from which the respective canes and renewal spurs arise, as shown in Figure 256. This system has the disadvantage, among others, of requiring extra labor for summer tying of the shoots to the upper wires. The *Munson* system is especially suited to home vineyards where there are several varieties in the planting. The trellis resembles a T-type telephone pole with three wires on which the vines are trained. It is easy for a person to cross from one row to another under the trellis in cultivation, spraying, and harvesting. Small fruits which are tolerant of some shade, such as currants, gooseberries, and raspberries, can be planted in the row between the vines. The *arbor* system for grapes is frequently used in the home landscape. Placement of trunks, canes, and spurs is similar to that for the Kniffin system, except more wood is left to provide shade at the sacrifice of some fruiting (Figure 257).

COST OF GROWING GRAPES

Labor and material costs for growing grapes vary from season to season and from one location to another. The following cost account Tables 37

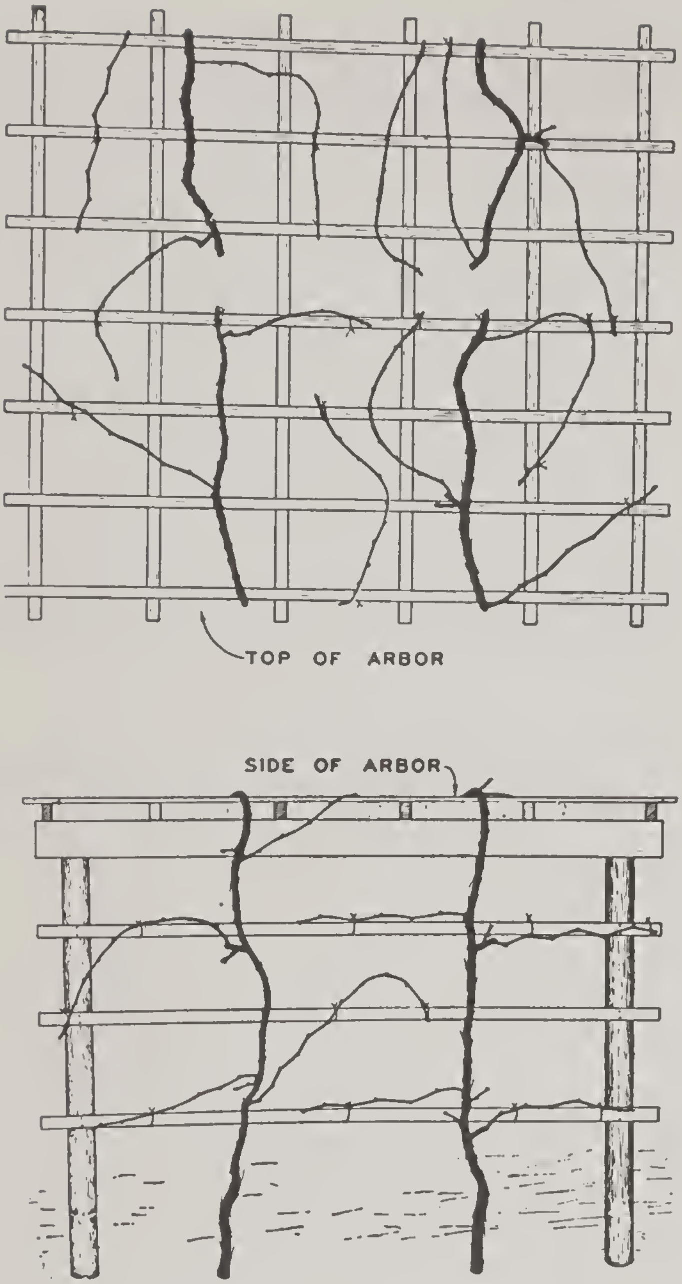


Figure 257. On backyard arbors, more fruiting canes are left than for trellis pruning because shade as well as fruit is desired. A modification of the Single-Trunk-Kniffin plan of training can be used. The diagram shows vines after pruning.

and 38, obtained from a group of Concord grape owners in northern Ohio are given only as guides for computing costs in any one vineyard. The figures are based on a relatively good-crop prewar year (1937) when prices were somewhat more stable than during the war or postwar periods. Average yield per acre was two and one-half tons under average vineyard management. Obviously, with yields of from three to six tons per acre or more, which are entirely feasible with continued good management, the cost per ton can be proportionately reduced.

Labor costs were figured at 30 cents per hour which was the prevailing rate in this part of the Lake Shore grape belt at the time these data were collected. Labor costs were double or more during war and postwar periods and will certainly vary from year to year, but this record should give some idea of the number of hours of labor used per acre in growing an average two and one-half-ton yield of Concord grapes with average vineyard management. Likewise, costs of materials can be adjusted to prevailing prices in order to arrive at a fair estimate of the total costs likely to be encountered in growing Eastern-type grapes.

The actual cost of producing a ton of grapes from year to year will vary chiefly with the yield. Low-ton costs per acre are possible only with high-ton yields.

HARVESTING AND MARKETING GRAPES

Stage of maturity. It is a common mistake to pick grapes too early. Unlike most fruits, there is practically no increase in color and sugar in

TABLE 37

COST PER ACRE OF ESTABLISHING A THREE-YEAR-OLD CONCORD VINEYARD IN NORTHERN OHIO

(Adapted from Beach)

MATERIAL COST—			
640 vines at $30.00 per thousand		$19.20	
210 posts at 32c each		67.20	
Wire (3 strands—13,500 ft., 525 pounds, 11 gauge at 75c per cwt.)		3.95	
Braces for end posts		5.00	
Fertilizer first year	$1.75		
" second year	2.00		
" third year	1.00	4.75	
Total material cost			$100.10
LABOR COSTS (man labor at 30 cents per hour)—			
Plowing, fitting, trenching (first year) (33 hours)[1]		$10.00	
Planting vines (23)		7.00	
Placing posts and wiring (50)		15.00	
Cultivation first year (13)		4.00	
" second year (20)		6.00	
" third year (40)		12.00	
Fertilization first year (25)	$0.75		
" second year (35)	1.10		
" third year (15)	.50	2.35	
Trimming second year (3)		1.00	
" third year (8)		2.50	
Tying—second and third years (16)		5.00	
Pulling pruned wood off wires and burning—second and third years (5)		1.50	
Total labor cost (221.2)			$ 66.35
USE OF LAND (valued at $100 per acre)—			
5½ per cent interest and 1½ per cent taxes for three years		$21.00	
Interest on $19.20 for 3 years at 6 per cent		3.46	
Interest on $76.15 for 2 years at 6 per cent		9.14	
Total overhead cost for 3 years			$ 33.60
Total cost for 3 years			$200.05
Credit for grapes harvested			10.00
Total cost			$190.05

[1] Approximate man hours required in parentheses.

grapes after they have been removed from the vines. Sour, poorly colored grapes on the market discourage subsequent sales.

The time for picking grapes depends upon the particular way in which they will be used. For jelly making, the fruit should be picked somewhat early in order to obtain light clear jelly free from crystals. For table use, grapes are picked when color and flavor are at the peak and before berries begin to shatter from the bunch, which varies with the variety. For juice, the grapes should be allowed to hang until full maturity is attained. Full maturity can be judged only from experience with a given variety. Some in-

TABLE 38

ANNUAL COST PER ACRE OF OPERATING A CONCORD VINEYARD AFTER THIRD YEAR, BASED ON 2½-TON YIELD

(Adapted from Beach)

LABOR COSTS (man labor at 30 cents per hour)—		
Trimming (11 hours)[1]	$ 3.25	
Pulling brush and burning (11)	3.50	
Tying (11)	3.25	
Repairing posts and wires (most labor) (10)	3.00	
Spring disking and plowing (13)	4.00	
Horse hoeing (6)	2.00	
Hand hoeing and applying fertilizer (6)	2.00	
2 cultivations (10)	4.00	
Fall plowing (1 furrow) (6)	2.00	
Picking (2½ tons at 4c per basket) (28)	8.48	
Hauling to barn ($1.00 per ton) (8)	2.50	
Extra labor in harvesting (10)	3.00	
Spraying—two applications at $3.25 per application for labor and machine (21)	6.50	
Drilling cover crop and fertilizer (5)	1.50	
Total annual labor cost (163.2)		$ 48.98
MATERIAL COST		
250 lbs. sulfate of ammonia	$ 3.75	
250 lbs. 4–10–6 fertilizer	3.15	
Strings or wires for tying	1.00	
Spray material (2 applications at $1.75 each)[2]	3.50	
212 baskets at 5c each	10.60	
2 bu. rye	1.50	
Total material cost per year		$ 23.50
OVERHEAD COSTS		
Annual depreciation of vineyard based on 20 years of life	$ 5.87	
Annual interest and taxes on land (7 per cent of $100.00)	7.00	
Total overhead cost per year		$ 12.87
Annual acre cost		$ 85.35
Cost per ton (2½ tons per acre)[3]		$ 34.14

---

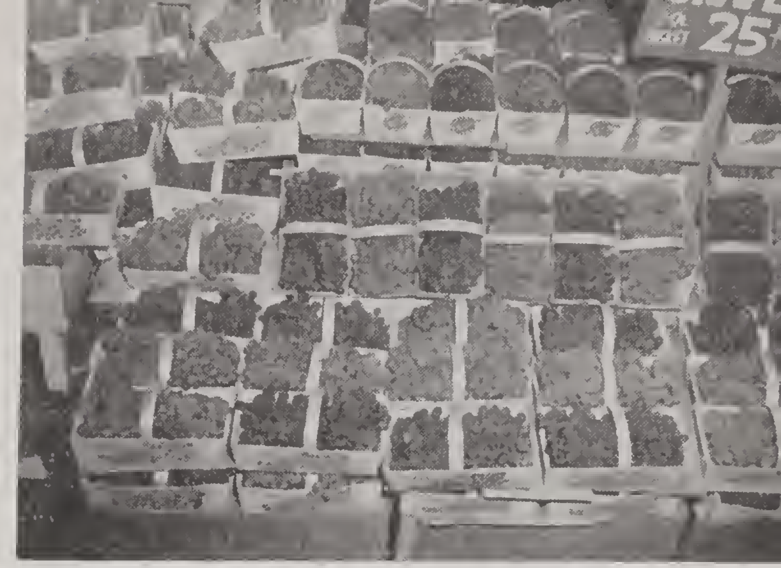
[1] Approximate man hours required in parentheses

[2] Number of applications will vary with the prevalence of insects and diseases in a given vineyard. The superiority of DDT in berry moth and leafhopper control may increase profits with little increase in spraying costs.

[3] Farm to market and selling costs are not included, since this varies considerably depending upon local marketing conditions.

dications often used to judge maturity other than by taste are browning and slight shrivelling of the stem, ease of separation of the berries, browning of the seeds, freeness of the seeds from the pulp, and a reddening or browning of the wood.

Containers. Containers should be ordered well in advance of the picking season. The number and type needed will obviously depend upon the amount and quality of the yield. Yields vary tremendously with variety and growing conditions. Concords may vary from one to eight tons per acre. An average commercial yield in the better northern Ohio vineyards is about two and one-half tons with some growers obtaining yields up to six tons per acre. Profit is doubtful with yields under two tons. Weak-growing varieties such as Delaware and Catawba average around one to two tons per acre, occasionally reaching four tons. These varieties, however, may demand double or more the price of Concords on the market.



Dick Meister, *American Fruit Grower* magazine, Cleveland

Figure 258. An enticing display of northern Ohio Fredonia and Niagara grapes in a Cleveland supermarket. The two-quart cartons with wooden handles and the different colored grapes are attractive; cellophane covers will preserve freshness and add attraction.

The climax baskets of the two-, four-, and twelve-quart size are popular for use with the bunch grapes. The wooden baskets with the wire handle or the cardboard baskets with single or doubleweight walls and a wooden handle are gaining in popularity in the Great Lakes regions. Cardboard containers are light, somewhat more economical, and better suited to advertising copy on the sides (Figure 258). The two- and four-quart containers are commonly used for table grapes, whereas the twelve-quart basket and the bushel or half-bushel basket are employed for juice or wine purposes. The wooden lug box (Figure 259) with outside dimensions of 24 inches in length, twelve inches wide, and six inches deep is used in large commercial areas where the fruit is sold for juice or wine. The bushel basket is actually a questionable container, even for juice purposes, since crushing of the berries and leakage often occurs if the grapes are picked wet.

Picking and packing. Grapes for table use should be handled carefully from the time they are picked until sold. Preserve the powdery bloom on the berries as much as possible. Handle the bunches by the stems and do not pull them from the vines. Remove bunches with special shears or a sharp knife. The better bunches on a vine are picked first and packed as Fancy or Number 1 grapes,[1] whereas the imperfect bunches are picked later and packed as Number 2 grapes. The poorer small bunches may be placed in a separate large container for juice. In packing the basket, it is placed on the picking stand (Figure 260) in a slanting position and the corner nearest the picker is filled first with the stems pointing downward. The picker then proceeds to fill the basket from bottom to top until the farthest corner is filled last. The baskets are carefully packed to about an inch above the rim, after which they are placed in the shade of the vine until taken to the shelter house, which should be as soon as possible. The grapes should be allowed

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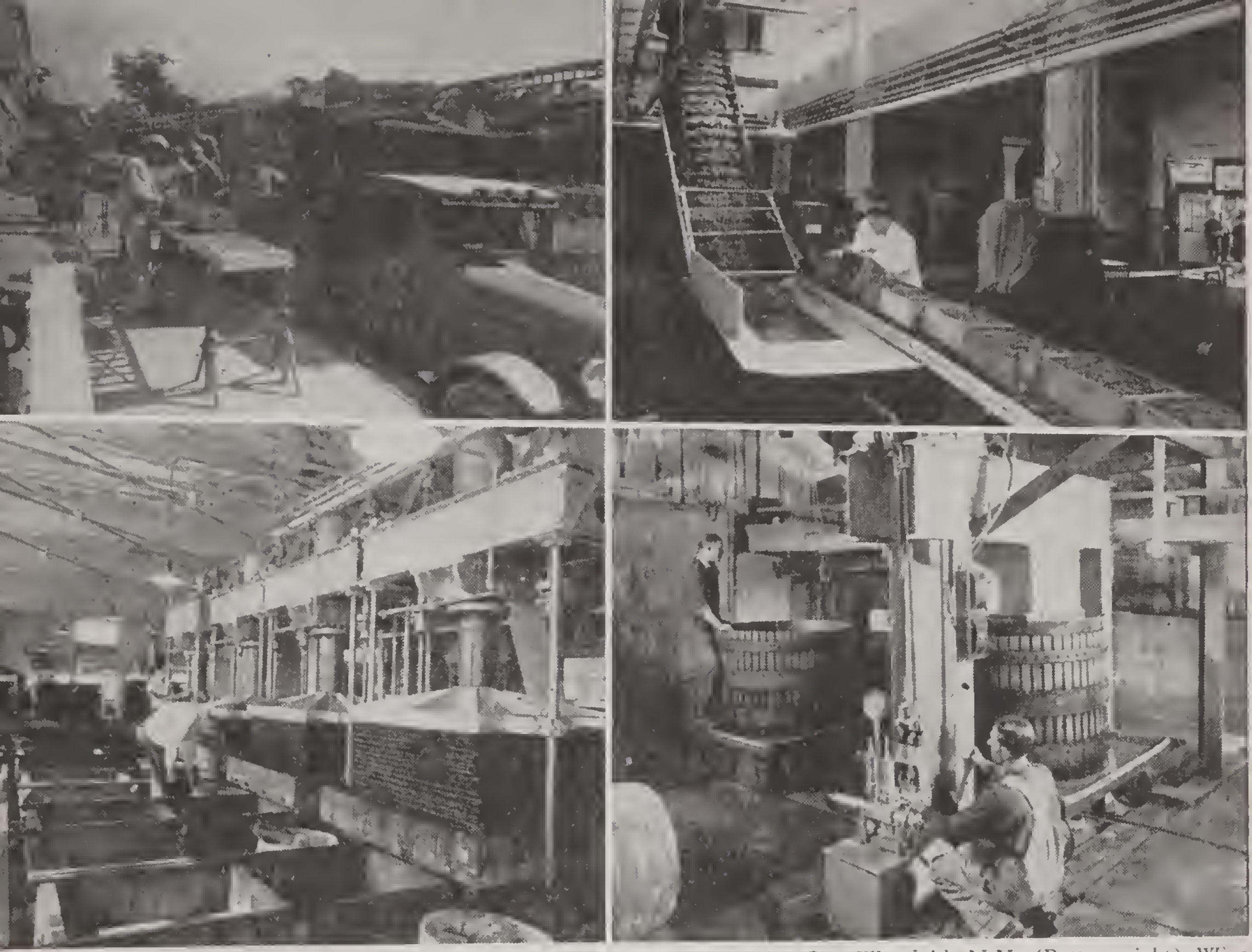
[1] For all government grade specifications for Eastern and Western grapes, contact the Farm Products Inspection Service, Production and Marketing Administration, U. S. Dept. of Agr., Washington, D. C.



(Top left, Top right, and Bottom left) Welch Grape Juice Co., Westfield, N.Y. (Bottom right) Wine Institute, San Francisco

Figure 259. The processing of Concord grapes for juice in western New York. (Top left) Grapes unloaded, government inspected, and sent to washer as shown in top-right photo. Grapes are washed in fresh water, picked up on cleats, thoroughly rinsed, and elevated to stemmers, then to hydraulic presses shown in bottom-left photo. In bottom-right picture is a common-type hydraulic grape press used in California Wineries. Note pressure gauge and extra basket.

to settle from four to six hours before tops are applied. Many baskets are sold, however, without tops.

For the higher grade packages, the small, poorly colored, diseased, or insect-infested berries can be removed at picking and packing time, provided the current price will justify the extra labor. Cloudy dry days are best for picking. Decay is likely to occur if grapes are picked wet.

Marketing. It is important that the grapes be taken to market on the day they are picked, or not later than the next day.

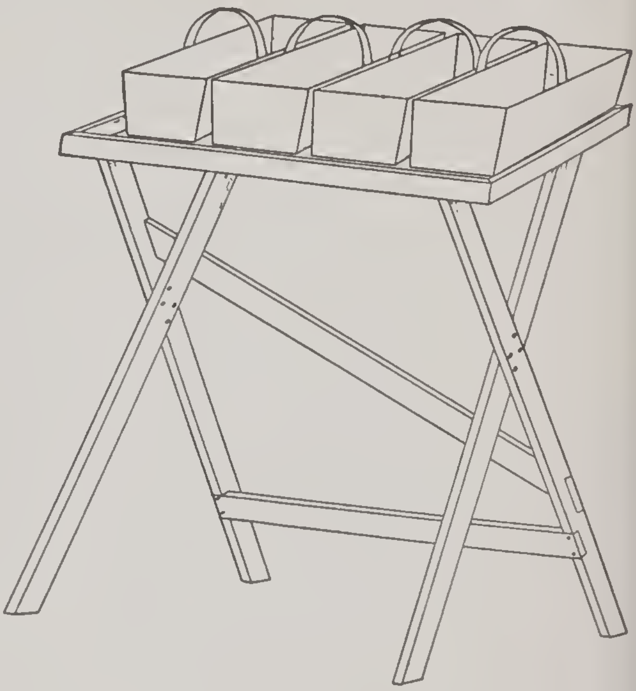
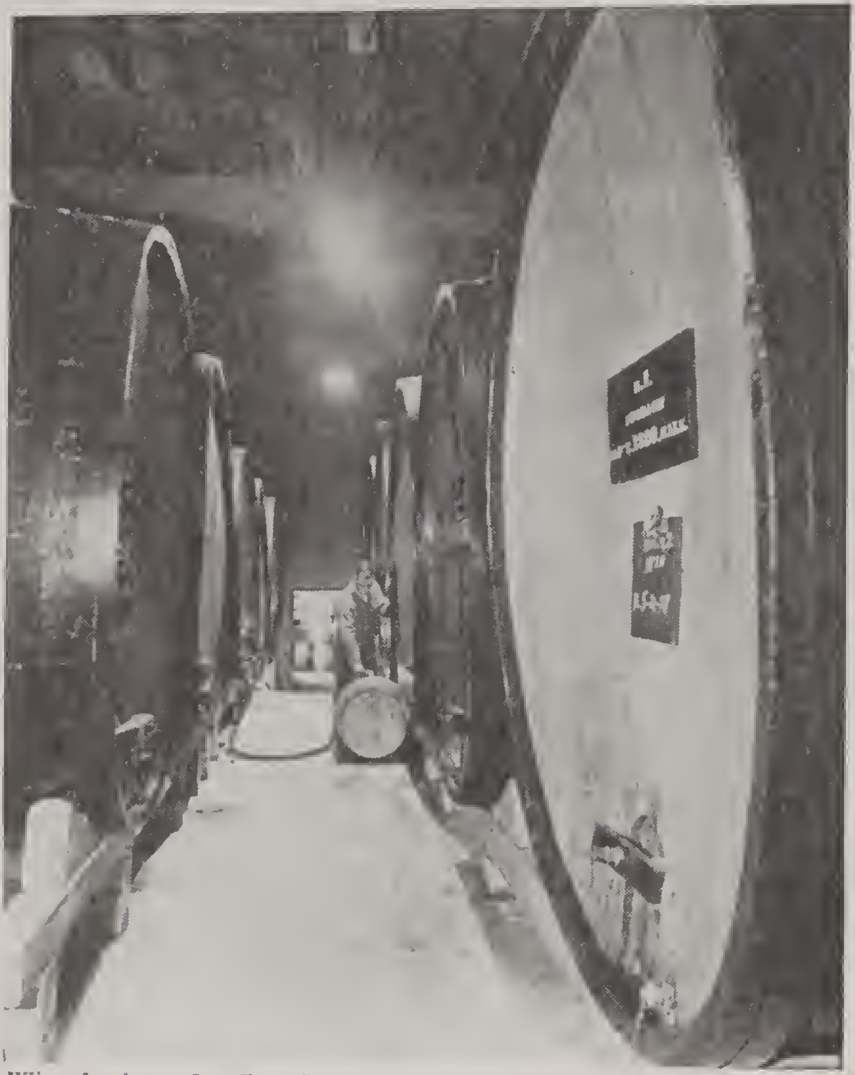


Figure 260. A light portable picking stand is convenient for filling baskets along the trellis. It should be about waist high to discourage pickers from dropping bunches into containers.

The less they are handled from picking until they reach the consumer, the better. If a roadside stand is available near the main highway, a portion of the crop can be disposed of through this channel. It is possible to save on container costs by removing the grapes from the cartons and placing them in paper bags for the customer. Large retail stores have been known to co-operate with the growers in this procedure and return the majority of the containers for second and third use. It should be borne in mind, however, that the basket tends to hold slightly more fruit when used more than once.

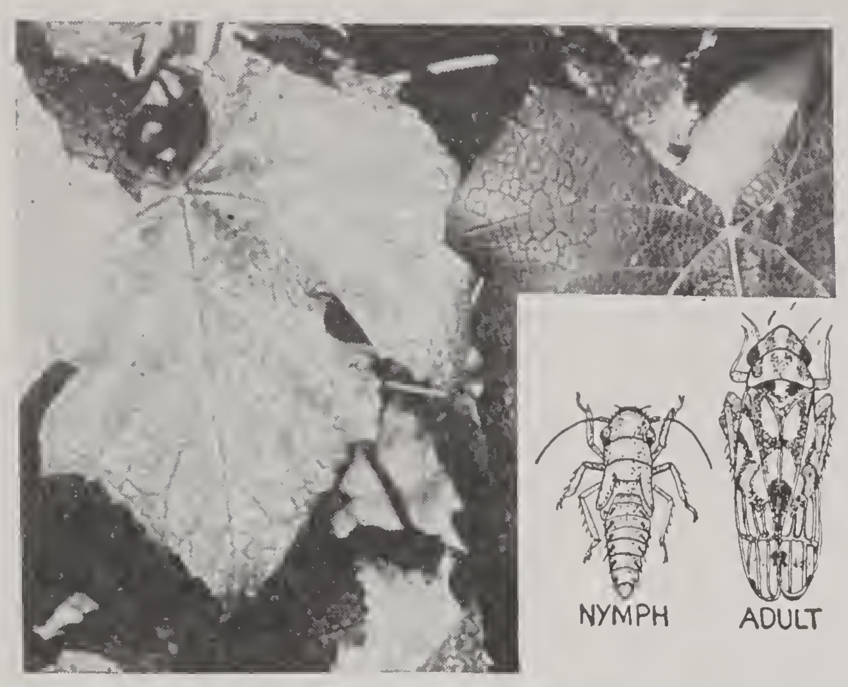


Wine Institute, San Francisco

Figure 261. About one-fifth of the United States grapes are made into wine. California produces over 80 per cent of this wine, or around 70 million gallons annually. Per capita wine consumption in the United States is about one-half gallon per year; in France 30 gallons, and in Italy 25 gallons. This picture shows 1800-gallon oak oval storage casks in a California winery.

Grape juice and wine offer large outlets for grapes (Figures 259, 261). In fact, these marketing channels are extremely valuable during seasons when there is a heavy supply of grapes on the fresh-fruit market. The northern states ship large quantities of table grapes by refrigerator cars and trucks to the states further south. Specific instructions for packing grapes for shipment can be obtained from the local freight station. It is important that grape baskets be packed solidly; a car of loose baskets is a juice factory on wheels.

During seasons of keen competition when labor costs are not out of reason, it may prove profitable to mix red, white, and blue grapes together in the basket at the packing shed. The return for this type of pack is often five cents more per quart basket, which is more than five times the labor involved. In season, another venture is to mix apples, peaches, pears or other fruits with the grapes in two-quart containers. This, also, makes an attractive family package.



(Top) George W. Stili, U.S.D.A. Grape Insect Laboratory, Sandusky, Ohio

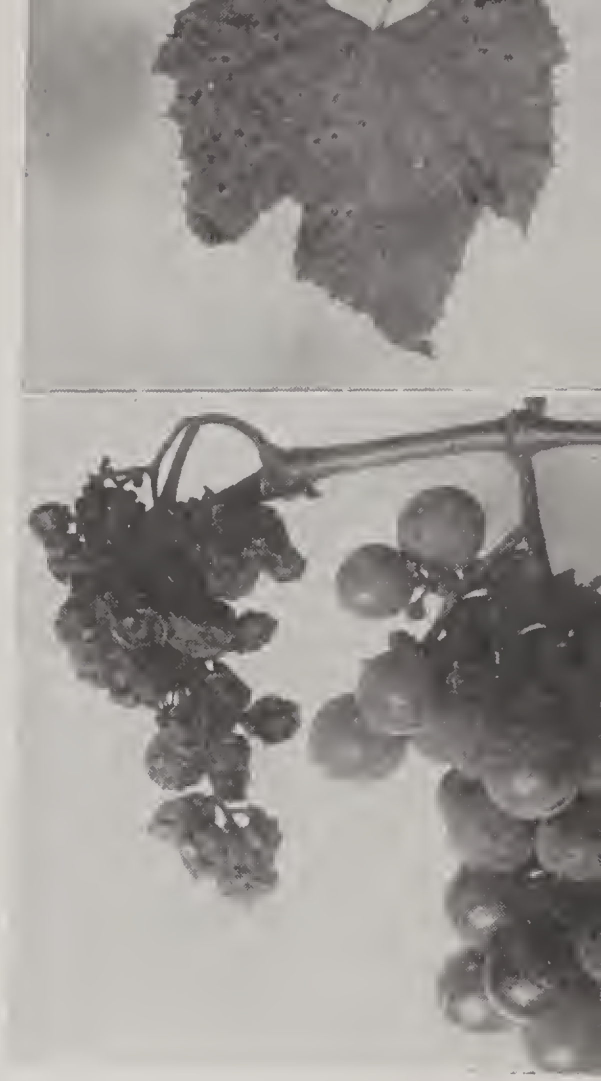
Figure 262. The grape leaf on the left has been fed upon by a large population of leafhoppers; the one on the right was taken from a vine sprayed at proper intervals with nicotine. DDT is also highly effective in leafhopper control. A nymph and adult grape leafhopper are shown at lower right; normal length of adult is about ⅛ inch.

Storing grapes. Grapes cannot be stored successfully for more than about one or two months. During a season when there is a heavy supply of grapes, it may be desirable to store a portion of the crop for later marketing. Grapes should be stored immediately after picking, using only the Fancy or No. 1 grapes which are in sound condition. They should preferably be placed in cold storage at about 30° F. with a humidity of about 85 per cent. Stack the containers with frequent aisles running both vertically and laterally in order to provide free air circulation. To reduce mold development, it is a common practice to spray the storage room and picking boxes with a solution of two pounds copper sulfate with 50 gallons of water several days before picking starts. The better keeping varieties are Delaware, Diamond, Agawam, Catawba, Sheridan, Vergennes, and Caco. The red grapes are usually better keepers than the black, white, or blue varieties.

Controlling insects and diseases. Insect and disease problems vary in different vineyards. It is, therefore, impossible to recommend a spray schedule for grapes that will have general application. For a given vineyard, it seems desirable to study the quality of the crop previously produced and the type of insect or disease injury, if any, which was present. If one or more insects or diseases persist in appearing year after year, the spray or sprays designed to correct these troubles should be used. Thorough application of spray to both the upper and lower surfaces of the leaves, properly timed, and using the proper materials is highly important in producing good-quality grapes.

The following is a brief description of the common diseases and insects in eastern grape-growing regions. *Grape-berry moth:* Small brown worms that develop in the fruit, causing it to color prematurely. Infested berries later crack open or shrivel and drop from the bunch. *Grapevine flea beetle:* Small, steel-blue jumping beetles that eat the opening buds in spring and destroy the new canes and fruit. The dark brown larvae feed on upper surface of the leaves in June. *Grape root worm:* Small, grayish-brown beetles which eat chain-like marks in the upper surface of the leaves in June and July. Larvae feed on grape roots. *Rose chafer:* Long-legged, yellowish-brown beetles about one-half-inch long. They eat blossom buds, newly-set fruit, and foliage and are limited principally to sandy areas of vineyards. *Climbing cutworms:* Brown cutworms that hide on the ground near canes by day and feed at night on the opening buds in early spring. *Leafhoppers:* Very small elongate pale green insects marked with yellow and red, which jump from the leaves when disturbed. They suck sap from underside of leaves, causing speckled or rusty appearance of upper surface of leaves (Figure 262). *Black rot:* The fruit rots, blackens, shrivels, and is covered with tiny black pimples. Leaves show brown spots having gray centers with black pimples (Figure 263). *Downy mildew:* Leaves have indefinite yellowish areas above with white downy patches beneath. Young shoots are covered with white downy mildew. Fruit has poor size, color, and flavor while some berries cease development and show gray mold on the surface. If almost mature, they shrivel, dry completely, and turn brown.

Example of a spray program used to control chiefly the above insects and diseases is shown in Table 39. Inasmuch as spray recommendations for grapes vary considerably from region to region and vineyard to vineyard, it is wise to follow the spray program outlined by the local experimental station.



American Fruit Grower magazine, Cleveland

Figure 263. (Top) Black rot is one of the worst diseases of *Labrusca* grapes. It appears on leaves during rainy periods in June and July. Spots are small, translucent in center, browning toward the outside with concentric rings, pinhead black pimples, and a black-line margin encircling the spot. (Bottom) Berries infected with black rot shrivel into hard black mummies covered with numerous tiny pimples. Most mummies shell and fall to the ground.

Spray machinery. No spraying is usually required during the time the vineyard is coming into production and in some cases during the early years of bearing. As the vineyard becomes older, however, diseases and insects tend to accumulate and may become a more serious problem. From 150 to 250 gallons of spray are required per acre of grapes for proper coverage. The spray should be applied at a pressure of about 250 pounds or higher, using a sprayer with adequate capacity to cover the vineyard in three or four days (see Chapter XVII for details on equipment).

For commercial spraying of large acreages, the standard orchard sprayer equipped with a fixed covered boom is economical and highly effective (Fig-

TABLE 39

Ohio Grape Spray Program, 1947

(From Ohio Agr. Ext. Serv. Bul. 129)

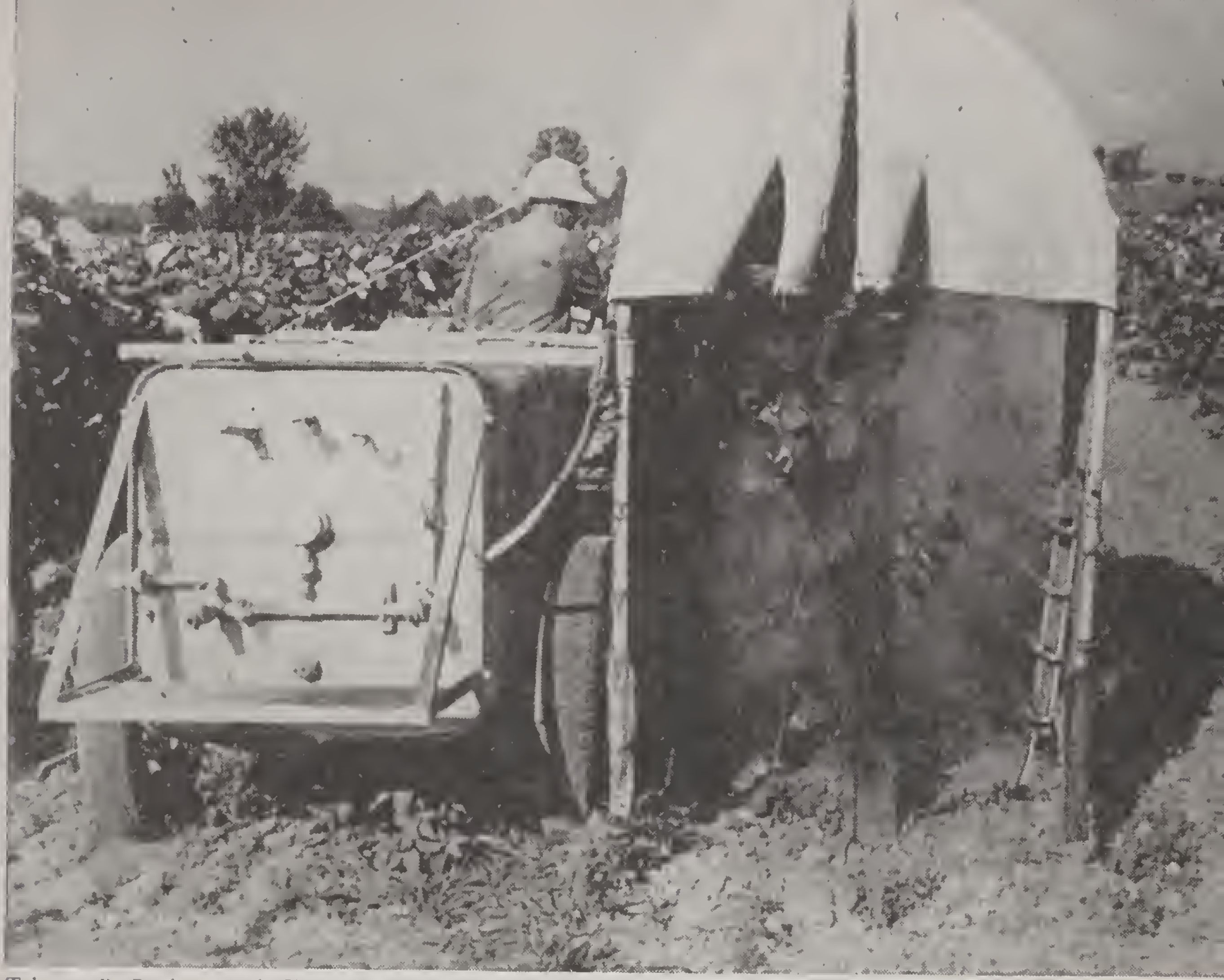
Name and Time of Spray	Materials to Use	To Control	Further Suggestions
Delayed Dormant Shoots ½"–¾".	4–6–100 bordeaux mixture.[1] Summer spray oil—2½ qts.	Black rot	In localities where black rot has been serious, watch out for injury to buds by climbing cutworms. To aid in the control of berry-moth worms, plow to vines as soon as soil can be worked. Plow under all fallen leaves and trash in which cocoons are located. Do not work soil again until 10 days after bloom. Apply about 125 gals. per acre of spray.
Prebloom *2nd Delayed Dormant* Shoots 10"–12" long just before bloom.	4–6–100 bordeaux mixture.[2] Summer spray oil—2½ qts.	Black rot	Spraying needed where these diseases occur. Cover all leaves and bud clusters. Watch for rose chafers which may appear just before bloom and destroy blossom buds. If they appear, spray with 2 lbs. of DDT (50% strength) in 100 gals. of bordeaux as soon as first noticed. Apply about 125 gals. per acre.
1st Cover Spray 7–10 days after bloom.	4–6–100 bordeaux mixture.[1] DDT—1½ lbs. Summer spray oil—1 pt.	Black rot Mildew Berry-moth Leafhopper Root-worm	Spray undersides of the leaves and clusters. Soil plowed for berry-moth control can be worked down. Apply about 200 gals. per acre.
2nd Cover Spray 30 days after 1st cover.	DDT (50%)—1½ lbs. Water—100 gals.	Berry moth Mildew[2]	Strike grape clusters with spray. Apply 200 gals. per acre.
3rd Cover Spray 15 days after 2nd cover but *not* later than 30 days before harvest.	DDT (50%)—1½ lbs. Water—100 gals.	Berry-moth Mildew[2]	Strike grape clusters with spray. Apply 200 gals. per acre.

[1] On varieties and in locations where mildew is not a factor, Fermate 1½ lbs. per 100 gallons of spray may be substituted for bordeaux.

[2] On varieties and in locations where mildew is prevalent, use 2-3-100 bordeaux or fixed copper 1 lb. (based on 50% copper content) plus 3 lbs. hydrated lime in all cover sprays.

ure 264). Covered booms are available on the market or can be constructed at home. They are usually provided with three nozzles on either side and one spraying from above. The upper nozzle may be closed in the early sprays but is very essential in the afterbloom sprays.

Where a small acreage of grapes is involved and it is impossible to especially equip the sprayer for grape spraying, the orchard outfit can be used



Tobacco By-Products and Chemical Corporation, Louisville, Ky.

Figure 264. The covered boom affords good spray coverage on grape foliage and fruit. It traps and covers leafhoppers and can be used effectively on windy days. Some rigs are equipped with two hoods for double-row spraying. Hoods can be made collapsible by hydraulic mechanism.

by one or two men trailing hoses and guns behind, with each man spraying only one side of the row at a time. Regardless of the method followed, however, only thorough work will control the pests effectively.

A few grapes in the home garden can be developed with practically no insects or diseases by placing paper bags around the bunches when the berries are about half grown. The bags should be fastened tightly around the stems by using paper clips, a stapling clamp, or string. Bagging is too expensive for commercial use.

GROWING MUSCADINE GRAPES

The growing of Muscadine grapes in the southeastern states is limited to areas where the temperature rarely goes lower than 10° F. and practically never reaches 0° F. With legalized wine since 1933, a number of large Muscadine vineyards have developed for wine manufacture which is the largest single outlet. Other uses of Muscadine grapes are in preserves, jellies, and jams; the canned grapes are used in pies.

Propagation. Layering is the common practice; it is generally more successful than by cuttings. A 25 per cent or less "take" with Muscadine cuttings is due to a very hard wood that does not callus or put out roots freely. It may prove more satisfactory to purchase vines from the nursery, requesting two-year plants rooted by layering.

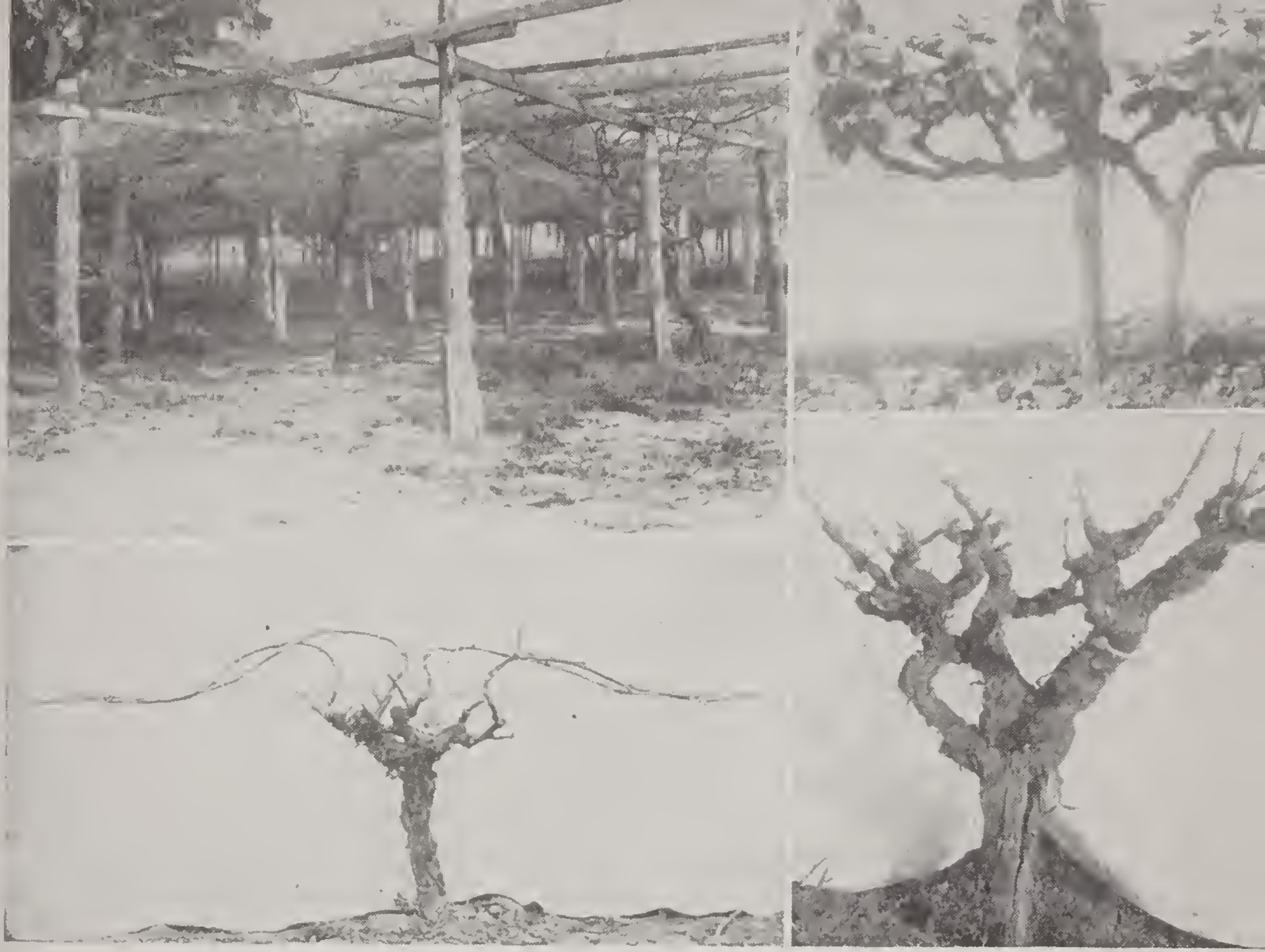
Varieties. *Scuppernong* ripens relatively early in the latter part of August. The vine is a rank grower, productive, and thriving best on well-drained sandy loam soils. It yields well but is not so productive as James or Thomas; it is suited to home use and wine making. *Mish* ripens uniformly but late. It is a fine all-round variety and next to Scuppernong as a wine grape. *James* is a vigorous slightly trailing vine with black fruit ripening late. It is an all-purpose grape, being good for dessert, market, wine, or culinary uses. *Flowers* ripens late. The black berries make good wine and although the skins are thick, they cook quite tender and are good for spiced grapes, conserves, and ketchup. *Thomas* ripens in early midseason. The dark wine-colored berries ripen unevenly and adhere poorly to the cluster. Flesh is tender, juicy, very sweet, and has an exceptionally rich fruity sprightly flavor. Thomas is the best standard variety for unfermented juice and preserve making. *Eden* ripens very early and uniformly, although the vines produce each season a distinct first and second crop. Eden is well adapted for wine making and for home and kitchen uses.

Planting distances. Rangy varieties like Scuppernong on vertical trellises may be planted ten feet apart in the row with rows ten feet apart, later thinning the plants in the row to 20 feet. For less vigorous varieties, the plants may be set 15 feet apart in rows ten feet apart. The overhead training system (Figure 265) for Scuppernong is laid out with posts 20 feet apart on the square. Vines are planted ten feet apart and thinned over a five- to ten-year period as crowding occurs, leaving permanent vines 20 feet apart at the posts. Intercropping is commonly practiced with Muscadine grapes.

Sterility. Most Muscadine varieties are self-sterile. Male vines which produce staminate flowers but no fruit must be interplanted for pollination. About 60 per cent of the wild grapes along the woods and in the hedge rows are male vines, but it is best to plant rooted layers of staminate vines which bloom heavily and at the same time as the pistillate vines in the vineyard. Every third vine in every third row should be a male vine, obtainable from southern nurseries.

Training and pruning. Muscadine grapes are trained to either a vertical or overhead trellis. The standard three-wire vertical trellis is adapted to the weak-growing varieties trained by either the Fan system or the vertical six-arm renewal system (resembling the four-cane Kniffin system, except there are six arms instead of four). The vertical trellis system has the advantages of costing 10 to 20 dollars less per acre to construct than the overhead system and the vines are more convenient to spray, prune, harvest, and intercrop with small fruits and vegetables.

The overhead trellis is popular for vigorous varieties (Figure 265), such as Scuppernong. It consists of durable posts and ten-gauge wire, affording a



(Top left) R. D. Dickey, Florida Agr. Exp. Sta. (Top right, bottom left, bottom right) H. E. Jacob, Calif. Agr. Exp. Sta.

Figure 265. Methods for pruning Muscadine and Vinifera grapes. (Top left) Seven-foot high overhead trellis is frequently used for Muscadine grapes in southern home and commercial vineyards. Two-wire vertical trellis is becoming more popular, however. (Top right) A mature horizontal bi-lateral Cordon-pruned Vinifera vine system is used for table varieties in California, particularly Malaga, Emperor, and Ribier. (Bottom left) A cane-pruned Vinifera vine on a two-wire trellis. The system is used primarily for raisin and wine varieties in California. (Bottom right) A head-pruned mature vine. The system used for vinifera varieties which bear well on spurs, including most wine grapes, the raisin Muscat, and a few table grapes, notably the Tokay. Note placement of trunk, arms, spurs, and canes from which fruiting shoots develop.

seven-foot clearance which permits cross-cultivation and grazing underneath by livestock; vines trained by this system are more likely to succeed under neglect. The posts are placed about 20 feet apart. The end posts are well braced with guy wires. A wire system is arranged across the tops of the posts so that four wires are attached to the top of each inner post, two running at right angles across the field and two running diagonally and at right angles to each other. This provides sufficient wires, radiating from the top of a post like the spokes on a wheel, to accommodate eight fruiting arms. If one old arm is cut back and renewed each year, this will mean that each of the eight arms will be renewed once in eight years. The canes in pruning are cut back to spurs about six inches long, each spur carrying from four to six buds. One arm, depending upon age, is capable of carrying many of these spurs.

Pruning can be done at any time when the vines are bare of foliage. The best time is after danger of freezing weather and before the buds start to swell.

Harvesting and handling. The average variety receiving good care should give 25 to 30 bushels of grapes per acre from four-year vines, 50 to 75 bushels from five-year vines, and 100 to 150 bushels from vines in full bearing. On the basis of 60 pounds per bushel, this is about three to six tons per acre. Varieties such as Scuppernong yield less than James and Thomas. Grapes for the winery or culinary purposes are harvested by spreading a canvas or burlap beneath the vine and jarring the grapes to the ground. Leaves and other debris are either removed by rolling the grapes on the canvas or by running them through a blower machine. Grapes for table use, including those that shatter from the cluster as well as those that remain attached to the cluster, are harvested carefully by hand and placed on the market in two- and four-quart climax baskets and the ordinary strawberry crates. The bushel basket is a common container for juice and wine grapes.

GROWING VINIFERA GRAPES

Over 90 per cent of the cultivated grapevines in the world are pure *V. vinifera.* In the United States, they are grown in the semiarid warm-temperate and subtropical regions of California, Arizona, and lower Texas along the Rio Grande River. The vines require a hot dry summer and a cool wet winter (rain may be replaced or supplemented by irrigation). A mean daily winter temperature of between 35° and 50° F., gradually rising to between 70° and 85° F. in summer is favorable. An average yearly rainfall of 20 to 25 inches is usually sufficient if well distributed during the autumn, winter, and spring. Regions where *vinifera* vines are grown in California have been shown in Figure 239.

Propagation. Rooted cuttings of the desired fruiting varieties can be used only in soils not infested with the Phylloxera insect or nematodes. In soils infested with these pests, cuttings of resistant rootstocks must be grafted to the desired fruiting variety either before (whip-graft) or after rooting (by whip-, cleft-, or groove-grafting or budding).

Planting distances. One hundred square feet or more are required per vine in fertile soils and hot climates where vines grow large. For cooler climates, less fertile soils or for smaller growing varieties, about 80 square feet or even less may suffice. Trellised vigorous raisin varieties are planted eight by twelve feet. For square planting and vines pruned to the vase-form (Figure 265), nine by nine or ten by ten feet are appropriate with avenues of 18 or 20 feet at intervals of 300 to 600 feet, or equivalent to the length of the irrigation furrows.

Vine supports. Varieties trained to the vase-form are supported by sticks four to six feet long. The sticks are removed after six to ten years when the vines become self-supporting. For a simple two-wire trellis, a substantial six-foot stake at each vine is sufficient with two No. 11 or No. 12 smooth galvanized fencing wires stretched along the row at 34 and 46 inches from the ground. For large-growing varieties, such as Thompson's Seedless, a "wide top" trellis is often constructed by tying a cross-arm (two by two inches by three feet) to the top of each alternate stake and bracing the lower end to hold the cross-arm at an angle of about 30° from the horizontal. Three wires are used on the cross-arms and one just beneath on the stake. Advantages of this system are more fruiting wood, clusters better exposed to light and air, better distribution of wood and bunches, and cultural operations are facilitated.

Pruning. Principles of pruning are similar to those for the Eastern grape. Three popular systems of training and pruning are shown in Figure 265, each adapted to the growth and fruiting habits of certain varieties. Head pruning is almost always used for wine grapes that bear well with short spur pruning, also for the Flame Tokay table grape and the Muscat raisin grape. Cane pruning is universally used for *vinifera* varieties that do not have fruitful buds near the base of the canes, such as Thompson Seedless, and also for such small-clustered wine-grape varieties as Sauvignon Blanc, Pinot Noir, and Chardonnay. Cordon pruning is used for practically all of the seeded table grapes except Tokay and some White Malaga. Pruning is done annually during the dormant season.

Thinning. Three types of fruit thinning are used on *vinifera* grapes; namely, flower-cluster thinning, cluster thinning, and berry thinning. Each type of thinning results in a reduction in the number of flowers or fruits and better growth and development of those which are left. The method of thinning used depends upon the type of fruit produced by a vineyard or a variety. *Flower-cluster thinning* is used on varieties which develop loose straggly clusters, such as Muscat of Alexandria and Dattier. The vines should be pruned with long spurs or fruit canes and some flowers removed as soon as possible after the clusters appear. *Cluster thinning*, or the removal of entire clusters soon after berries are set, is the most widely used. Enough wood is left at pruning time each year to produce a crop in so-called poor years, but if a good year later is in prospect, the overload is then removed by cluster thinning which results in large regular crops almost every year. *Berry thinning* is practiced by cutting off the end of the main stem and several branches of the cluster, or by cutting off enough of the main stem to leave only the desired number of berries. It is limited to varieties which set very compact or very large clusters. Berry thinning is practiced as soon as the berries have set.

Girdling. The removal of a 3/16-inch strip of bark from around the main trunk at blooming time increases the set of seedless berries. Girdling improves the yield of Black Corinth which normally sets straggly small clusters of mostly tiny seedless berries. Girdling is practiced on Thompson Seedless vines for increasing berry size of table grapes; it is performed as soon as possible after the berries have set. Thinning is usually necessary with Thompson Seedless to prevent overbearing after the vine has been girdled. Cluster thinning followed by berry thinning where needed is commonly practiced.

Irrigation. Irrigation is practiced in California chiefly in the interior valleys, and there are undoubtedly many vineyards in the south and north coast regions which would benefit from it. The technique of irrigation is much the same as that described for deciduous orchards in Chapter V.

Harvesting. *Table grapes.* Most California table grapes are marketed 2,000 miles or more from the vineyards. Transportation is by refrigerated railway cars; the time required for shipping is seven to eleven days or more. Proper time of harvesting is judged by the sugar content, using a hydrometer (saccharimeter) as described by Jacob. By experience, the picker judges maturity roughly by: (1) color and condition of the cluster stem; when top of cluster stem is brown and woody or when framework stems of cluster are light or straw yellow, (2) taste of the berries (used only at intervals due to a dulling of the taste), and (3) the characteristic change in color of berries of different varieties which is recognized only with experience. It is usually necessary to go over a vine three or more times in order to harvest most of the table grapes at the proper stage. *Wine grapes.* The picking time for wine grapes varies with the kind of wine to be made. Grapes are picked earlier for dry wines than for sweet wines. Grapes for dry wines are picked when the sugar content tests 18° to 23° Balling, while grapes for sweet wines are harvested usually at 24° Balling or more. For ordinary wine, the entire crop is harvested at a single picking which is the usual practice in California. Several pickings are made for very fine wine. The grapes are picked and hauled in field lug boxes or in bulk in truck loads and crushed as soon as possible. Grapes for raisins are picked at 23° Balling or more. The degree of maturity at which raisin grapes are picked is usually a compromise beween leaving the grapes as long as possible for better quality and heavier yield and yet to avoid the possibility of early fall rains which may interfere with sun drying. If the grapes are to be dehydrated in special ovens, weather conditions are a minor factor in picking, but the grapes must be removed before early rains cause deterioration on the vine.

Varieties. The chief raisin varieties are Thompson Seedless or Sultania (comprising over 80 per cent of raisin grapes in California), Muscat of Alexandria, and Black Corinth (Zante Currant). Principal table grapes are Thompson Seedless, Flame Tokay (second to Thompson Seedless in importance), Emperor, White Malaga, Red Malaga, Ribier, Almeria (Ohanez), Cornichon (Olivette Noire), Olivette Blanche, and Rish Baba. The black wine grapes consist of Zinfandel (leading wine grape in California), Carignane, Alicante Bouschet, Petit Sirah, Mataro, Cabernet Sauvignon, Grenache, Mission, and Malvoisie. White wine grapes include Palomino, Burger, Sauvignon Vert, Semillon, Sauvignon Blanc, Johannisberger Riesling, Franken Riesling, Green Hungarian, and Feher Szagos.

Diseases and pests. These include powdery mildew, black measles, black knot, Pierce's disease, little-leaf, Phylloxera, nematode, grape leafhopper, cutworms, red spider, grape leaf roller, rabbits, and gophers. Descriptions and control measures will be found in a bulletin by Jacob, listed under "Suggested Collateral Reading" on page 533.

Review Questions

1. Indicate the approximate regions where the European-, American-, and Muscadine-type grapes are grown in the United States.
2. What is the relative commercial importance of the above three types of grapes in the United States?
3. What are the five leading states in grape production and what is the relative importance of California?
4. What is the chief method for propagating the native American-type grapes?
5. What is the purpose of layering?
6. Briefly describe a soil management system for a (1) young and (2) mature vineyard in your locality, including recommendations for cultivation, cover crops, and manures or commercial fertilizers.
7. Diagram a method of bracing the end posts of a 2-wire grape trellis, giving necessary dimensions and specifications for posts and wires.
8. Diagram, label, and briefly describe the 4-cane Kniffin system of pruning a mature Concord vine.
9. How does pruning grapes on arbors differ from that described in the previous question?
10. How do you judge picking maturity for table grapes?
11. What type of spray equipment is most effective in insect and disease control in commercial vineyards in the East?
12. List two insects and two diseases which are important in the spray program of eastern-type grapes.
13. Essentially, how does the management of Muscadine grapes differ from that of the native American-type?
14. What are the main differences in cultural management of the *vinifera* grapes in California as compared with the native American-type grapes in the East?

Suggested Collateral Readings

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CHAPTER XXI

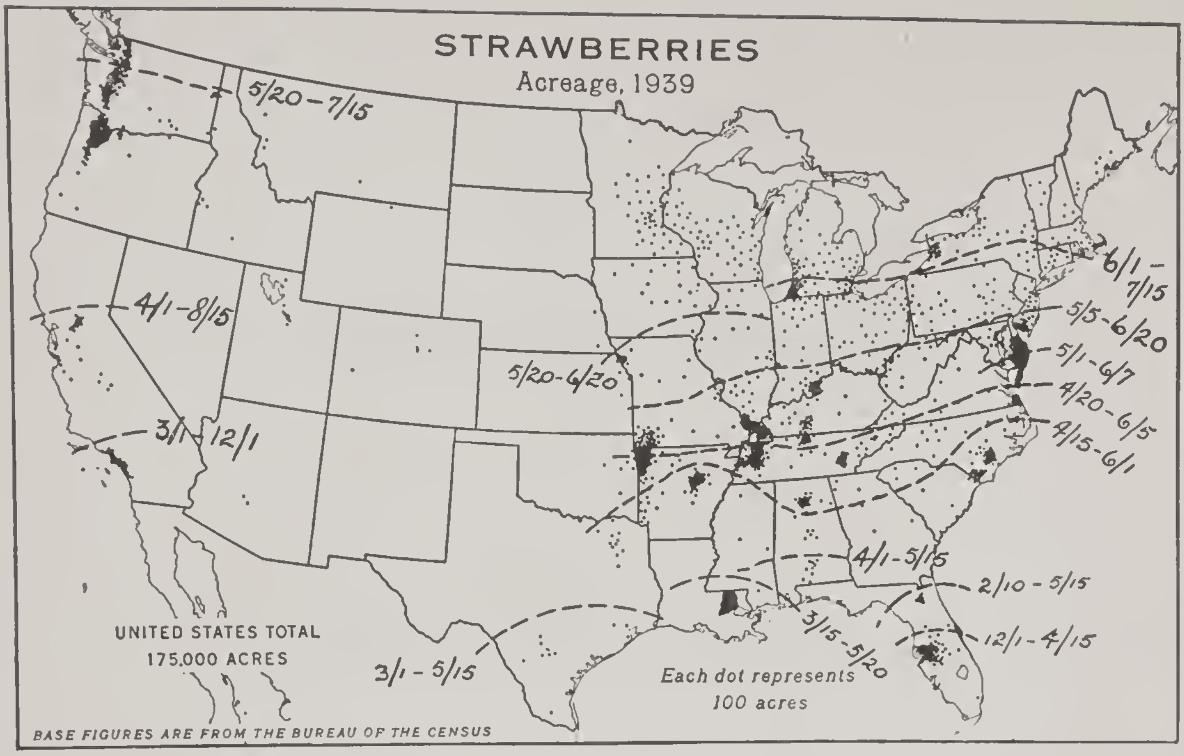
Strawberry Growing

The strawberry is among the first fresh fruits on the market in spring. It is in great demand locally in all regions in which it is grown, which comprise over three-fourths of the United States. Due to its wide adaptation to climate and soils, the strawberry is available fresh several months of the year from Florida to Alaska. In some sections of California it is available fresh every month of the year.

From the concentrated areas of production shown in Figure 266, especially in the South and Northwest, considerable quantities of strawberries are shipped to distant markets. In the eastern United States, the first commercial berries are harvested in Florida about December 1 (Figure 266), and as the season progresses northward, strawberries are shipped from Louisiana, North Carolina, Arkansas, Tennessee, Missouri, Kentucky, Maryland, and New Jersey. Among the last strawberries to ripen are those in the regions of New York, Wisconsin, and Washington.

The commercial strawberry industry is probably more equally distributed among southern and northern states than any other important fruit (Figure 267.) The ten leading states in production, according to the 1937–46 average (in thousands of crates) were Louisiana, 1103; Oregon, 840; Arkansas, 729; Michigan, 693; Tennessee, 599; Washington, 524; North Carolina, 409; Virginia, 375; California, 356; and Ohio, 305. During World War II, total strawberry acreage dropped from about 175,000 to 90,000 acres, but the price rose from a seasonal average of about $2.60 to over $10.00 a crate (Figure 268).

The following discussion will be devoted largely to the management of strawberries in the eastern United States since most of the crop is grown in this region. Culture in the West and South will be discussed only in so far as it differs from that in the East.



U.S.D.A. Bureau of Agricultural Economics

Figure 266. Strawberries are grown commercially from subtropical Florida and Texas to Minnesota and Maine. Concentrated areas of commercial production are shown in such states as Florida, Louisiana, Arkansas, Missouri, Tennessee, Illinois, New Jersey, and Oregon. Lines and dates show the approximate shipping season for each section. Shipments start about December 1 in Florida and continue to July 15 in New York, Michigan, and Washington.

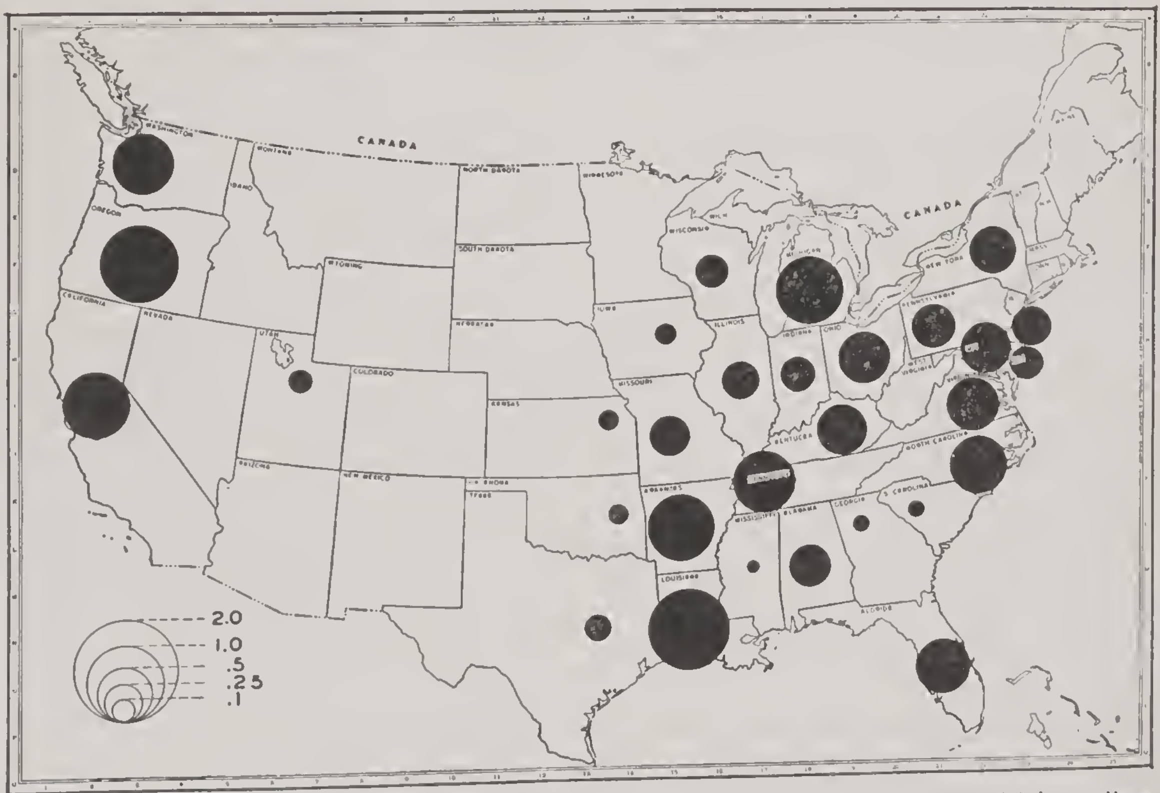


Figure 267. Although Louisiana leads in commercial strawberry production, many widely scattered states are close behind in productive capacity. Most of the crop is grown in central and eastern states. (Figures are in millions of crates and are based on the 1937–46 average.)

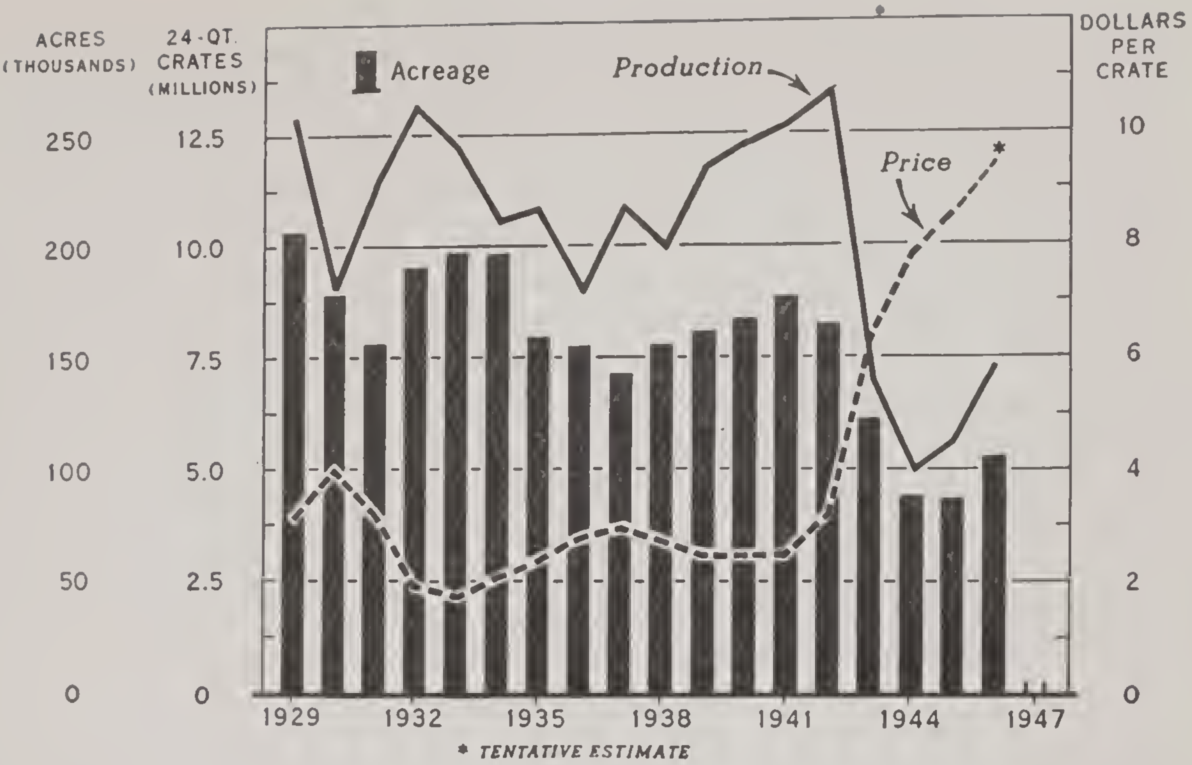


Figure 268. The United States commercial strawberry acreage, production, and seasonal average price to farmers, 1929 to 1946. Price is inversely related to production; production has tended to follow acreage.

LOCATING THE PLANTATION

Factors of first importance in locating a commercial strawberry plantation are (1) accessibility of markets, (2) transportation facilities, (3) adequate labor supply, (4) community interest, and (5) climate. If strawberries are to be grown for the general market, it is usually best to select a site among other growers. Thus, it is easier to obtain experienced pickers, and co-operative handling and buying of supplies are possible. Also, carload shipments can be made where several growers combine their crops; otherwise, small shipments may need to be made at relatively greater expense by express.

Before producing strawberries on a large scale, the grower should have reasonable assurance that there will be an adequate supply of labor, especially during the harvesting season. Under nonirrigation conditions, it requires the time of one man for each four or five acres up to harvest, whereas under irrigation it requires one man for each acre. Usually from five to ten pickers per acre are needed during harvest. Failure to secure labor during picking may result in severe losses.

Important factors in selecting the site are water and air drainage, slope, exposure of the land, and character of the soil. Because the strawberry grows close to the ground, the blossoms may be killed by spring frosts in years when fruit trees are unharmed. For this reason, it is particularly important to have good air drainage in frost regions. In California, frosts are of little or no concern.

The strawberry requires frequent cultivation and, consequently, sites with a slight slope are better than those with a steep slope. If steep slopes are used, contour plantings should be made with or without terraces in order to conserve soil and moisture; in fact, contour planting is considered good practice on sites with only a slight slope (Figure 276). Southern exposures absorb more sun heat and the berries may ripen several days earlier than those growing on a northern slope in the same locality. A succession of ripening can be obtained by placing berries on both the northern and southern slopes.

The strawberry can be grown on almost any type of soil, from poor sand to heavy clay, provided it is well supplied with moisture and organic matter and is well drained. Berries ripen somewhat earlier on sandy soil than on clay soils, other conditions being similar. There is a definite varietal adaptation to soils, some growing better on heavy soils and others growing better on light soils. There is less difference, however, within a variety when grown on different soils, provided the soils are all high in humus. In the West, it is well to avoid alkali soils, since strawberries are sensitive to this condition.

CHOOSING VARIETIES

The variety selected will depend upon the climate, soil, and the purpose for which the crop is grown. Experience of the growers in a given locality is one of the best guides in selecting profitable varieties. Some varieties bear firm berries well adapted to long-distance shipping. Others bear large attractive berries of excellent quality but too soft for long shipment and thus suitable only for local trade or home use. In recent years, special varieties have been originated for each region. For example, in the South, the Blakemore, Missionary, Klonmore, Massey, and Klondike varieties have been almost the only commercial varieties grown. The Aroma is a leader in and around southern Missouri and Kentucky. Howard 17 (Premier) is grown widely in the northeastern states from western Kansas and Nebraska to New Jersey and southern Maine. The Marshall variety is grown widely on the West Coast from southern California to northern Washington. Importance of varieties in the United States as a whole is shown in Table 40. For a detailed description of varieties and the regions in which they are best adapted, see Darrow and Waldo. Also, contact the local state college.

In the home garden, it is desirable to have varieties of excellent dessert quality which ripen in succession over a long season. For market gardeners who sell the berries closeby, the majority of the berries may consist of a variety not especially adapted to shipping. However, when local markets become overloaded, it may be wise to have one or two later ripening varieties adapted to shipping, for berries cannot be stored fresh more than about ten days.

When strawberries are raised for the general market, it is important to include only two or three varieties, since buyers prefer to obtain full truck- or carloads of one variety, rather than loads of mixed varieties which may differ in shipping quality and may have different flavors, colors, and shapes. In large shipping regions, not over three varieties are usually grown. In

TABLE 40

Principal Strawberry Varieties in the United States in Order of Importance. On Basis of Established Acreage in 1946

(Adapted from Darrow and Waldo)

Rank	Variety	Total Acreage	Rank	Variety	Total Acreage
		Per cent			*Per cent*
1	Blakemore	34.0	9	Fairfax	2.0
2	Howard 17	12.0	10	Lupton	2.0
3	Marshall	11.0	11	Redheart	1.0
4	Klondike	7.0	12	Beaver	1.0
5	Klonmore	7.0	13	Dorsett	1.0
6	Aroma	6.0	14	Massey	1.0
7	Missionary	4.0	15	Robinson	1.0
8	Catskill	4.0		Other varieties	6.0
				Total	100.0

regions where spring frosts are a factor, it may be wise to raise more than one variety so that if blossoms of one variety are killed, those of a later blooming sort may escape.

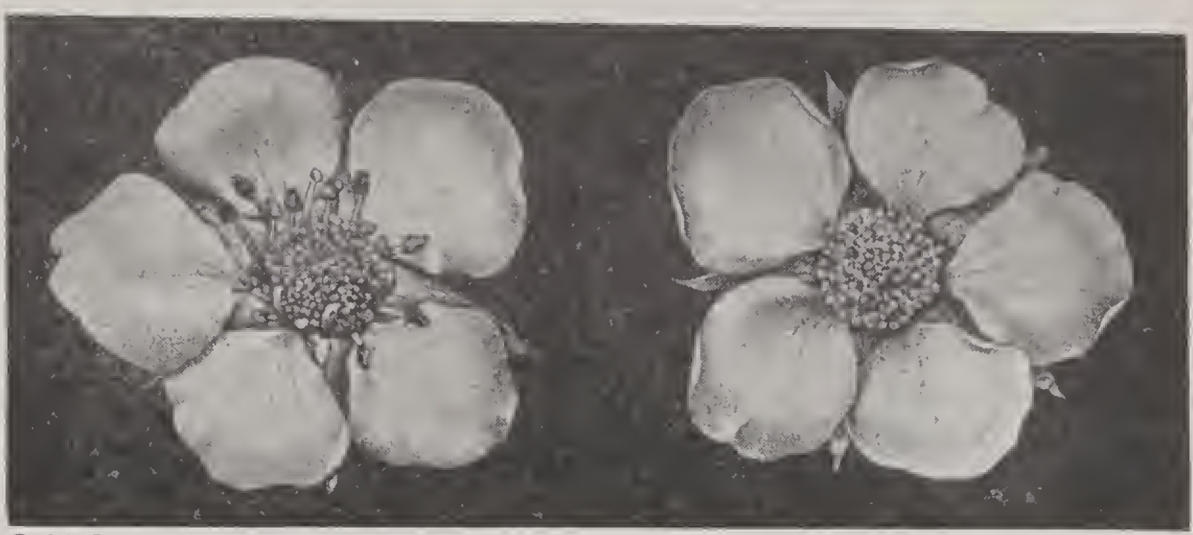
Perfect and imperfect flowers. Most commercial strawberry varieties have perfect flowers, which means that both pistils and stamens are present, as shown at the left in Figure 269. Perfect varieties can be planted in large single blocks with assurance of satisfactory pollination if other conditions are favorable. Some varieties, however, have imperfect flowers which have only pistils but no stamens. While imperfect varieties may have very desirable fruit and plant characteristics, there are perfect varieties available with equally good qualities. However, one of the chief advantages of varieties with imperfect flowers is the fact that the strawberry weevil does not bother the flowers in regions where this insect is troublesome. Where imperfect varieties are used, a perfect variety should be alternated with every two to three rows of the imperfect one.

In cool moist springs, the first flowers to open on some weakly-staminate varieties, such as Glen Mary, may produce bad pollen, resulting in many "nubbins" (deformed berries). Under these conditions, it may be wise to interplant with a strongly staminate variety, such as Marshall, Redheart, Fairfax, or Fairmore, to obtain better fruit set on the weakly staminate variety.

PROPAGATION

Strawberries are commonly propagated by runner plants. Plants raised from seed are undesirable because strawberry seedlings are too variable. The Rockhill variety (Wazata), a poor plant producer, is one of the few propagated by dividing the crowns of older plants. This method is too tedious and expensive, however, for varieties that produce runner plants readily.

Plants for spring setting. The plants can be secured from the nursery, or



G. M. Darrow, U.S.D.A.

Figure 269. (Left) A perfect or staminate strawberry blossom with both pistils and stamens. (Right) Imperfect or pistillate blossom with pistils but no stamens. Imperfect varieties will not give commercial production of fruit unless grown one or two rows from a variety with perfect pollen-producing blossoms.

the grower can propagate his own plants, the latter of which is commonly done. If the old planting is relatively free from diseases and insects and has not been injured by cold, young plants with vigorous roots and tops obtained from the outside of the old rows are quite satisfactory. Some growers dig up the entire matted row, obtaining from six good plants per linear foot from varieties like Marshall and Chesapeake up to 25 good plants from varieties, such as Blakemore and Missionary, under favorable conditions. This method of propagation is not recommended if the plants have been injured by cold or if the spring has been wet and planting has been delayed. Under these conditions, cold storage plants from the nursery are preferred to those dug fresh from the field. Some growers maintain a special strawberry nursery which, preferably, should be located on sandy soil.

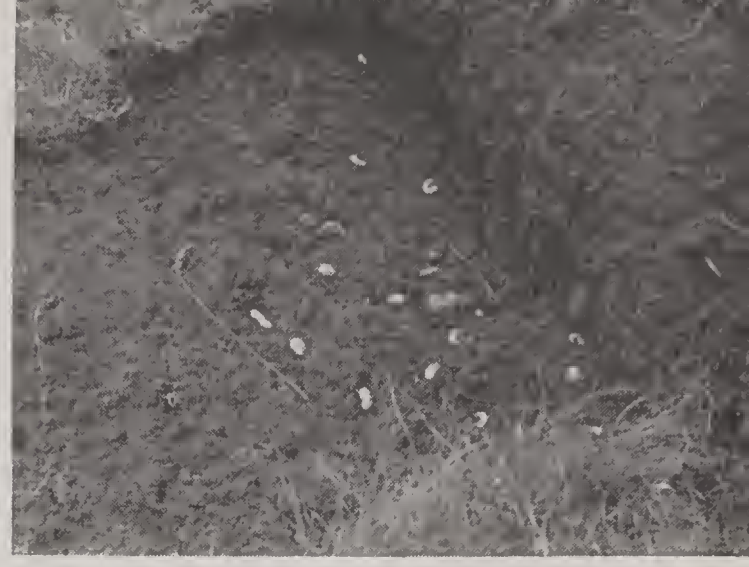
Plants for fall setting. Both field-grown and pot-grown plants are used for late summer (August) planting. Field-grown plants with the best root systems and largest crowns should be selected, leaving a small clump of soil about the roots of each plant. Protection of the roots from sun and wind injury is important.

Pot-grown plants are popular in home gardens. The pots are sunk in the ground near the parent plants and the first runners to appear are rooted in them. Good results can be obtained by this method because there is little or no shock in transplanting the strawberries to the field.

In southern California, plants for setting to the field are obtained from eastern nurseries because some dormant period is needed in the strawberry for vigorous growth later.

SOIL PREPARATION

Ground should be in cultivation for one to two years, preferably two years, previous to planting strawberries. Clean cultivation serves to free the



New York Agr. Exp. Sta.

Figure 270. Land should be in clean cultivation for a year before planting strawberries. This helps eliminate white grub worms, shown above, which normally infest sodded areas and will destroy newly set strawberry plants.

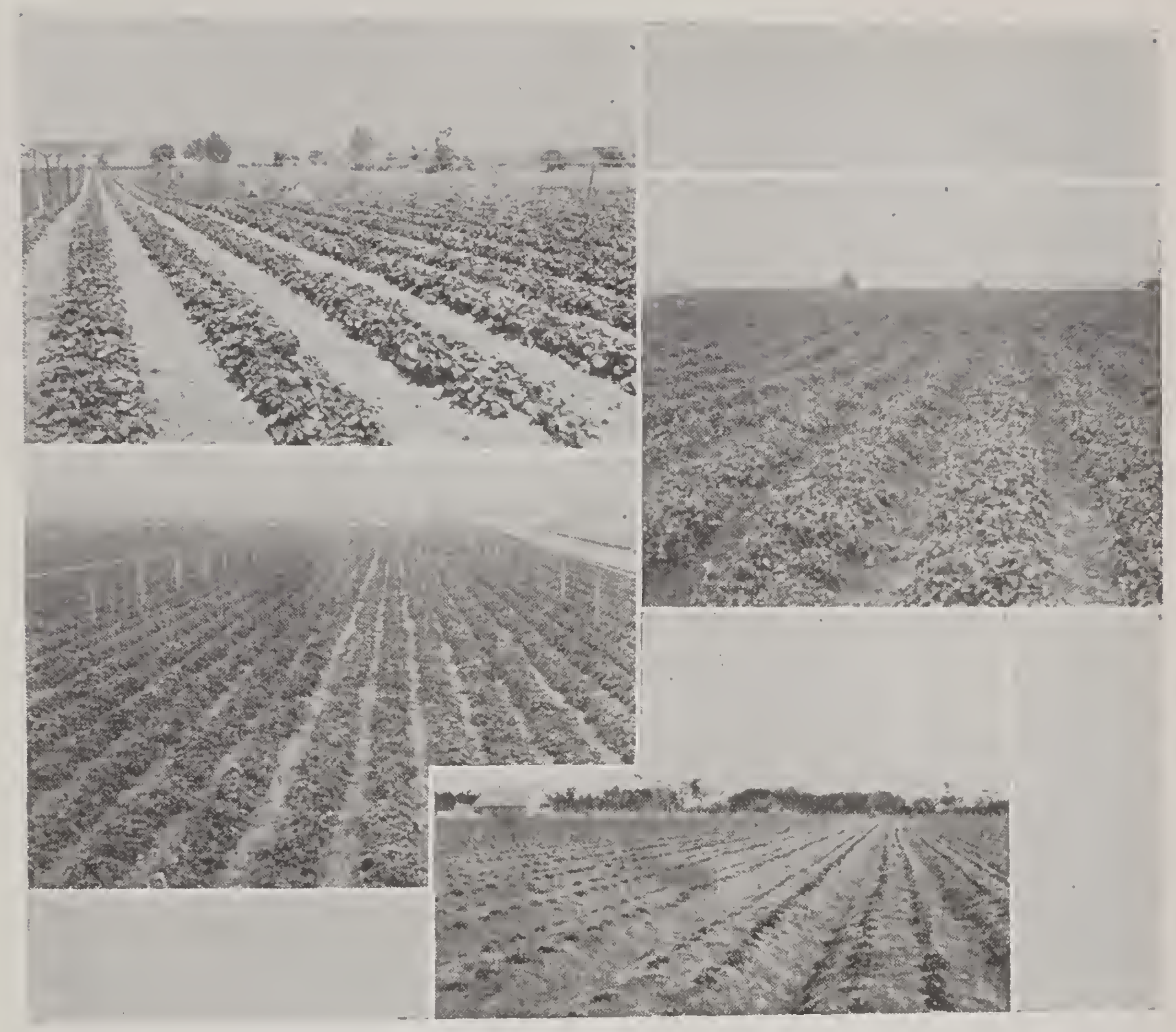
land of white grubs and quack grass or similar persistent weeds. Newly plowed grass-sod land is particularly undesirable because it usually contains many grubs of the June beetle (Figure 270) which weaken or destroy the young strawberry plants. The ground first should be plowed in autumn to expose the grubs and grass roots over winter. Suitable crops for the following season include sweet potatoes, tobacco, hoed vegetable crops, grain crops other than corn, or any legume, provided the soil is not too acid. If lime is applied to raise the pH to around 6.5, it should be applied before one of the rotation crops, and not before the strawberries which are particularly susceptible to lime burning. Strawberries should not ordinarily follow peas, tomatoes, white potatoes, and beets because of possible injury from diseases common to both crops, nor should they follow corn because of root aphis. A suggested rotation for the eastern states is (1) maintain the ground in clover for one or more years; (2) plow in autumn and sow rye and vetch or crimson clover; (3) plow in the spring and raise soybeans or some hoed vegetables; (4) plow again in autumn and sow crimson clover. Plow under the crimson clover the following spring and plant strawberries.

If it is the practice to grow strawberries on the same land for two or more years, the humus content of the soil should be increased before setting each new planting. This can best be done by applying eight to ten tons of manure to the crop preceding strawberries. If no manure is available, two green manure crops preceding the strawberries, both turned under, may be necessary on soils of low humus content.

Before planting strawberries, the land should be thoroughly pulverized and in most cases, leveled. Where ridges are needed on level somewhat poorly drained areas, they can be made by throwing two or more plow furrows together and leveling the top with a drag plank. In California, special mechanical equipment is described for building and leveling the ridges shown in Figure 271.

ESTABLISHING THE PLANTATION

Time of planting. Except in the southern and western states, fruit buds of the strawberry are formed in the fall of the first growing season. When spring planting is practiced, it is of paramount importance to set healthy vigorous plants *as early in the spring as possible* in order to develop the



(Top left, middle left, bottom center) G. M. Darrow, U.S.D.A. (Top right) University of California.

Figure 271. (Top left) Chesapeake strawberries grown in hills in double rows. (Top right) Contour raised beds with spaced rows as used in Watsonville area of central-coast district in California. (Middle left) Chesapeake strawberries grown in hills under irrigation. Third crop is being harvested from plantation in New Jersey on June 10. (Bottom center) Strawberry plants at Starke, Florida, February 6, set in double rows on raised beds.

required number of vigorous daughter plants by autumn. The larger the individual plants at the end of the first growing season, the greater the number of fruit buds formed and the larger the crop and the individual berries the following year.

In the eastern states, most of the planting is done in spring. If the weather is undesirable, plants can be held in storage at 31° to 32° F. until conditions are favorable. Although these plants from cold storage may not show many leaves at the time of planting, they usually grow much better than plants freshly dug from the field.

Fall planting in August is sometimes practiced near large cities in the region of New York, and a crop is harvested the following year. With this practice, the soil must be rich and irrigation should be available. Large plants with good root systems are set as close as four to six inches apart in rows three feet apart, using the double-row hill system.

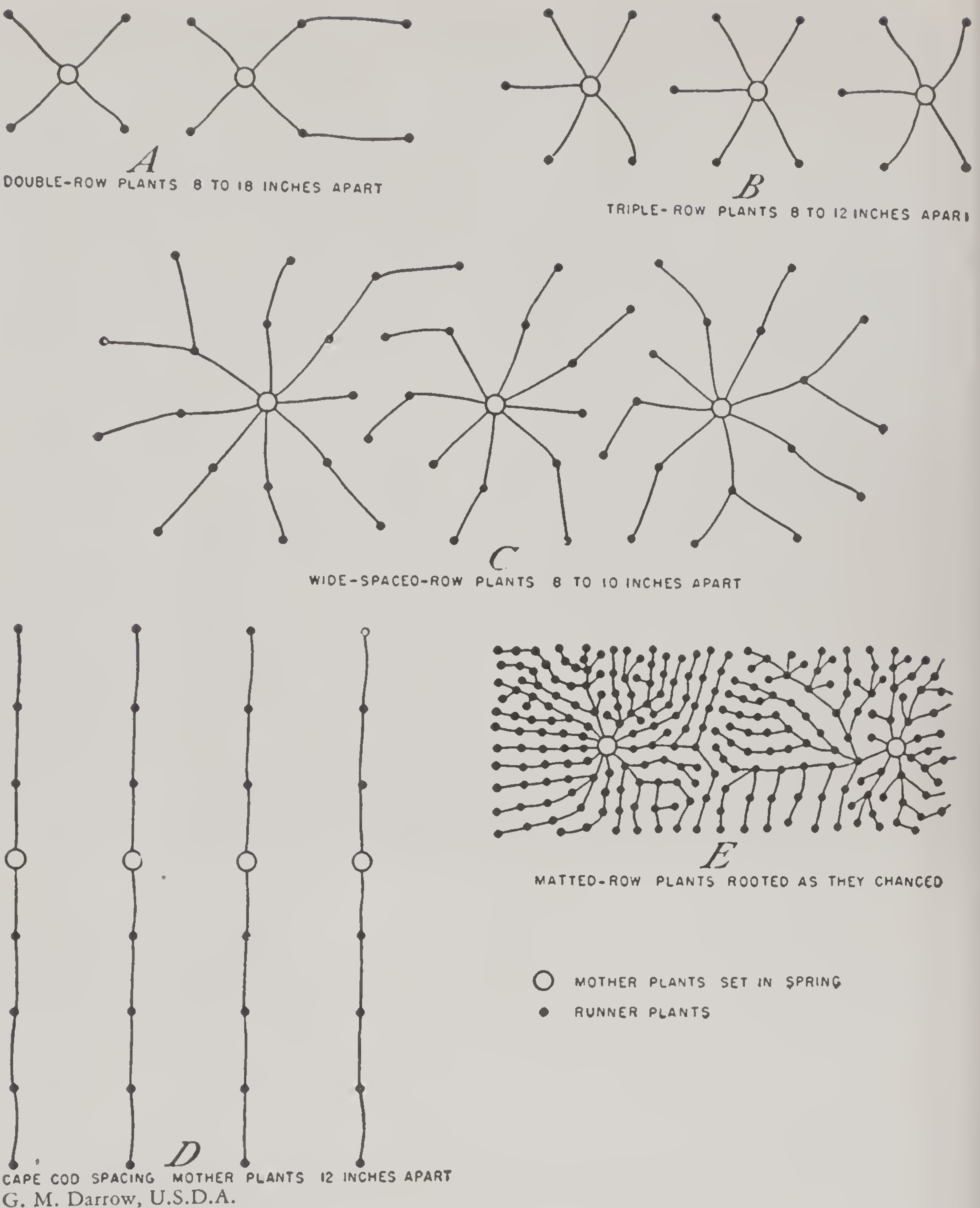
In the Northwest irrigated sections, early fall or early spring planting is preferred. In California, time of planting varies, depending upon when the rainy periods occur. In most of California, late fall and early winter are preferred. On sandy soils, plants can be set at any time during the winter but on heavy soils they should be set after the first rains. If rains become too heavy before the job is finished, further planting should be delayed until early spring. The last of September is a satisfactory planting time in Florida. In the Hammond, Louisiana district, plants produce well when set in November, or, as late as December 20. In southwestern Texas, plants are often set in early fall and a crop is harvested the next spring.

Training systems. Three training systems are in general use: (1) the hill system, (2) the spaced-row system, and (3) the matted-row system.

In the *hill* system, all runners are removed from the mother plant as they appear; no daughter plants are allowed to develop. This system is used with varieties such as Chesapeake, which naturally produce few runners and daughter plants. Individual plants become quite large and bear more than those in the matted-row system, described later. Plants are set 6 to 24 inches (commonly 12 to 18 inches) apart in rows three to three and one-half feet apart (Figure 271). With this system a small garden tractor or a field tractor can be used for tillage, greatly reducing expense of hand labor. In the home garden where hand labor is used, the rows can be spaced closer, or about 18 inches apart. Sometimes twin rows are set 6 to 24 inches apart; then a wider space is left and another two rows are set (Figure 271). In some cases, triple rows are set. However, these are only modifications of the hill system with the plants set the same distance apart in the row in each case.

The *spaced-row* system is also used for varieties which are moderate to weak in sending out runners and producing daughter plants. In this system, the daughter plants are spaced at definite distances by covering selected runners at the enlarging "nodes" until the desired number of daughter plants is obtained for each mother plant. Later-formed runners are either removed as they appear or all surplus runners are removed at one time, using special tools described later.

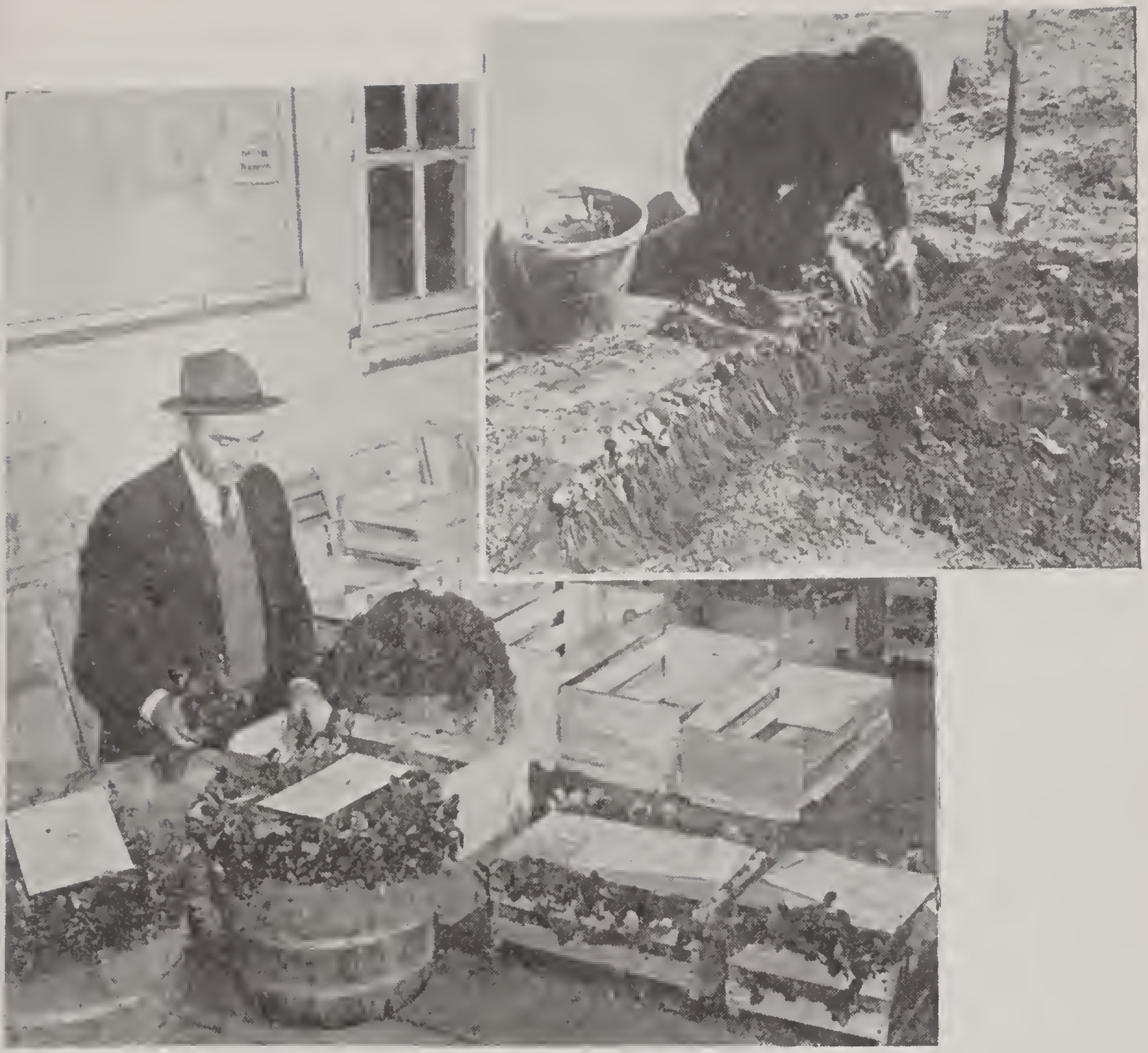
In the region of Cape Cod, Massachusetts, spacing is a general practice. Mother plants are set about 12 inches apart, and two runner series are allowed to form, one with three and the other with four daughter plants, as shown in Figure 272. Plants grow large under this system and produce as much as 8000 to 9000 quarts per acre. In other sections, each runner plant is rooted at distances of six to twelve inches apart and after the stand is complete, all subsequent runners are removed. Rows are allowed to develop 24 to 30 inches wide which produce large crops of fancy berries. In a spacing test with the Blakemore variety, 30, 4, 1.8, and ⅔ of a plant were left per square foot of row. Respective yields were 42, 119, 131, and 99 bushel crates of marketable fruit per acre. Under conditions of this test, 25,000 to 100,000 plants left to fruit per acre were best. All plants in excess of this number were actually weeds competing for moisture, space, and plant nutrients.


A
DOUBLE-ROW PLANTS 8 TO 18 INCHES APART
B
TRIPLE-ROW PLANTS 8 TO 12 INCHES APART
C
WIDE-SPACED-ROW PLANTS 8 TO 10 INCHES APART
E
MATTED-ROW PLANTS ROOTED AS THEY CHANCED
○ MOTHER PLANTS SET IN SPRING
● RUNNER PLANTS
D
CAPE COD SPACING MOTHER PLANTS 12 INCHES APART

G. M. Darrow, U.S.D.A.

Figure 272. Spacing systems in common use for strawberries. Spaced-row systems shown in *A*, *B*, and *C* are most commonly used, but that shown in *D* is used extensively on Cape Cod, Massachusetts; some of the highest yields of fancy fruit are produced by these spacing methods. Matted-row system at *E* is used almost exclusively with Aroma and Dunlap varieties.

With the *matted-row system,* the plants are set 18 to 42 inches apart in single rows three to four and one-half feet apart. All, or a large part, of the runners that form during the first summer are allowed to take root and produce daughter plants between the mother plants. A mat of plants forms by the end of the first season, varying from a few inches to two and one-half to three feet in width and in some cases may even reach four or five feet. Harvesting is easier with the matted-row system if the rows are narrow, or not wider than two feet. Some growers maintain the width of matted rows



(Bottom) F. W. Allen Co. Salisbury, Md. (Top) G. M. Darrow, U.S.D.A.

Figure 273. (Bottom) Young strawberry plants are brought from the nursery in bushel baskets and packed in peat moss in different size slatted crates according to request. (Top) Strawberry plants should be heeled-in if they cannot be set to the field immediately upon arrival. Roots are separated and each plant is placed in a trench and firmly covered with soil to the crown.

at about 12 inches. Twin matted-rows are sometimes allowed to form, 6 to 24 inches apart, then a wide alley is left and two other rows, 6 to 24 inches apart are formed. The two rows may be formed by permitting a 24- to 30-inch wide mat to form, then plow up the center 12 inches of the row.

Chesapeake or similar varieties which do not form runners readily should not be set further apart than 18 inches in the matted-row system. Dunlap, Blakemore, Dorsett, Aroma, and Catskill, which form runners readily, may be set at greater distances apart. Where there is danger of some loss from white grubs or severe drought, planting distance in the rows should not exceed 18 inches for all varieties. On steep slopes, rows should be at least four feet apart. Plants of a given variety should be set further apart on fertile land than on land low in fertility.

Although the matted-row system of growing strawberries is probably the simplest and least expensive to handle, production records of high-quality fruit have not equaled those where the plants are spaced by hand. In fact, as strawberry production becomes more and more intensive in a section, the

TABLE 41

Number of Strawberry Plants Required to Set an Acre When Spaced at Different Distances

(Adapted from Darrow)

Distance (feet)	Plants to the Acre	Distance (feet)	Plants to the Acre	Distance (feet)	Plants to the Acre
	Number		*Number*		*Number*
3 by 1	14,520	3½ by 1½	8,296	4 by 1	10,890
3 by 1½	9,680	3½ by 2	6,223	4 by 1½	7,260
3 by 2	7,260	3½ by 2½	4,980	4 by 2	5,445
3½ by 1	12,446	3½ by 3	4,148	4 by 2½	4,356

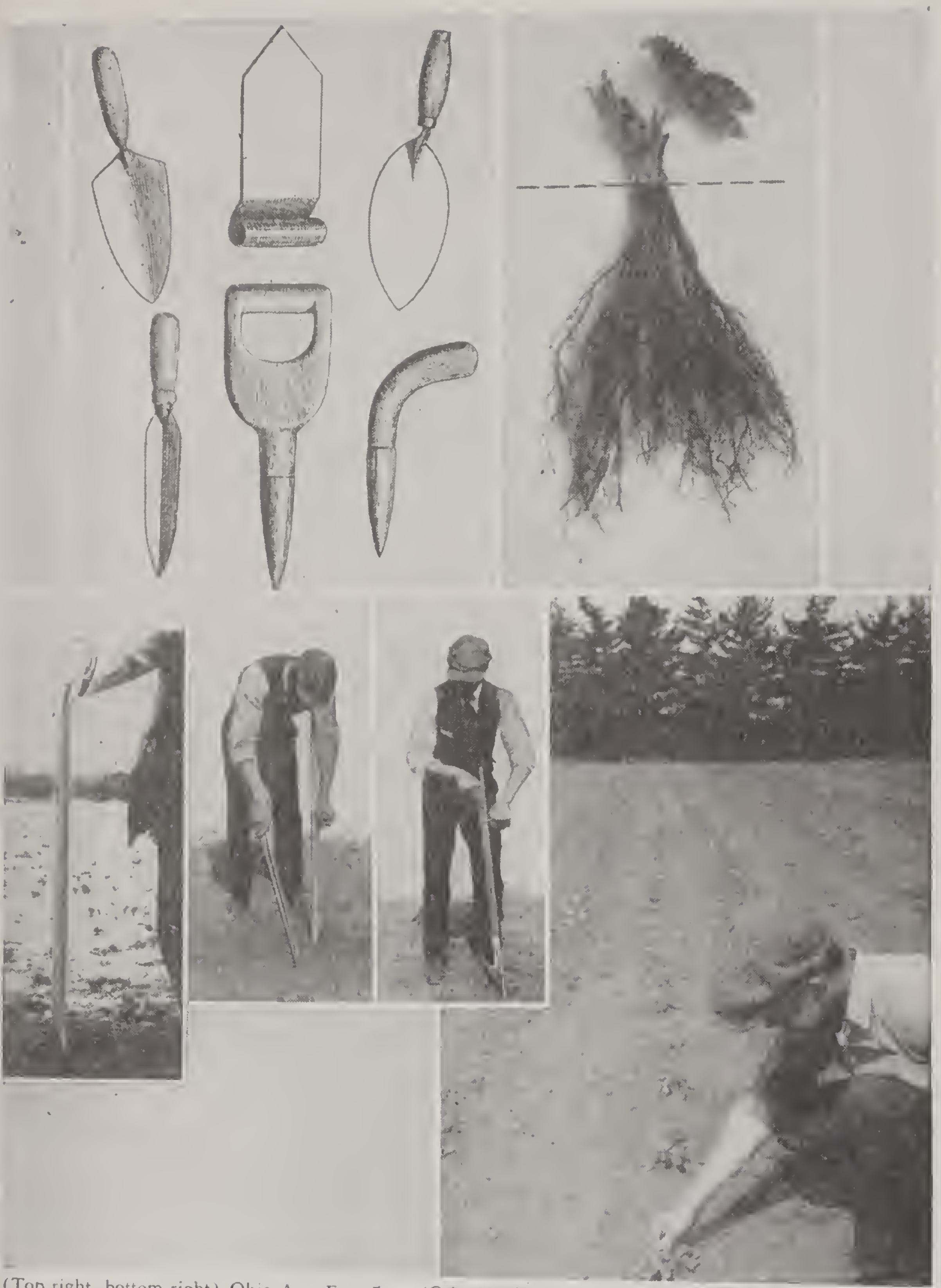
growers are forced to adopt some method of spacing the plants. Of course, the cost of growing an acre in spaced rows is higher than in matted rows and the grower must consider the cost difference against any increase in returns in his locality in deciding which system to use. It should be pointed out that the matted-row system is probably best suited to regions where there is considerable danger from severe drought, severe winters, or white grubs. Although these factors may be responsible for death of many of the plants, a sufficient number under this training system usually survive to give a good stand.

Some varieties give better yields in the hill and spaced rows than in the matted-row system, whereas others perform best in matted rows. Chesapeake and Marshall are usually grown in hills, whereas Aroma and Dunlap are grown almost entirely in matted rows. The latter two varieties form so many runners, in fact, that it is too expensive to attempt to properly space them. Also, the Aroma variety makes a few crowns per plant, even though the runners are removed.

Marking rows. On level ground, a plank or pipe to which chains are attached at points corresponding to the planting distance can be dragged across the field. Plants set in straight lines and evenly spaced rows are much easier to cultivate and maintain than when the rows are irregular. Plants set in check rows can be cultivated both ways until the runners begin to grow freely. No marking of rows will be necessary if the plants are grown on ridges. Rows should run the long way of the field for convenience and economy in cultivation. On sloping land, they should run on the contour.

The planting distance is governed, as pointed out previously, by the system of planting used, the plant-making habit of the variety, the slope, the soil, the climatic conditions, the danger from white grubs, and the cost of labor. Table 41 gives the number of plants required to set an acre at different planting distances.

A large number of extra plants should be ordered for replanting if there is danger of loss from grubs, drought, or other factors. A field with many blank spaces is too costly to maintain on the basis of value of the crop obtained.



(Top right, bottom right) Ohio Agr. Exp. Sta., (Others) G. M. Darrow, U.S.D.A.

Figure 274. Planting strawberries. (Top left) Types of dibbles and trowels used in transplanting strawberries. (Top right) Strawberry plant ready to set with long roots shortened and with all but one healthy leaf removed. Proper depth of planting is indicated by broken line. (Bottom left) Paddle for setting strawberry plants when soil is very mellow. Plant is dropped and the roots forced into the ground with a dull steel-tipped paddle; soil is firmed with the foot. (Bottom middle left) A punch and tongs for setting strawberry plants. Hole is made with punch, the plant is picked up and placed in the hole with the tongs, and the earth firmed about it with the foot. (Bottom middle right) A packer. The strawberry plant is forced into the ground with the paddle and the earth firmed around it with the packer which is fastened to the paddle handle by clips, and, thus, it works up and down on the handle. (Bottom right) Strawberry blossoms must be removed early in the summer following planting. Flowers weaken plant and reduce yield if allowed to remain the first growing season. For everbearing varieties, blossoms can be left after about July 1 for fall crop.

Care of plants on arrival. Plants are prepared at the nursery in bunches of about 25 and packed in peat moss in different size slatted crates, as shown in Figure 273. If on arrival, the plants cannot be set to the field immediately, they should be heeled-in on a well-drained and protected spot, as described in Figure 273. Roots on good plants should be fresh and slightly yellowish in color, or somewhat dark if grown on muck soil. Old and undesirable plants can be distinguished from young plants by their black and dead roots. Plants coming from the nursery should be protected from the sun and wind by covering them with a piece of wet burlap or other wet material.

Setting the plants. The plant in Figure 274 has a healthy vigorous root system, is properly trimmed, and all but one good leaf has been removed. It is ready for planting. Two things are important in setting strawberry plants: (1) Set each plant so that the crown is even with the surface of the soil after it has been packed about the roots (see dash mark in Figure 274); and (2) firm the soil well around and over the root system. Plants may be set either by hand with a dibble, spade, or punch (Figure 274), or with a two-wheel planting machine similar to those used for setting vegetable plants on a large scale.

One man working by himself may set around 5,000 plants a day. If he has a boy helper who carries the plants in a bucket of water and hands them to him, his capacity is increased by three or four thousand in a ten-hour day. A short-handled hoe in one hand is convenient to open the hole for planting.

With a planting machine, about 25,000 plants or three to four acres can be planted in a ten-hour day. One person drives the tractor or team and two others are seated at the rear of the planting machine close to the ground where they can drop plants alternately as the machine opens and closes the furrow and applies water from a large barrel. When planting by machine, the plants should be relatively uniform in size, roots straight, trimmed, and arranged in one direction in the plant holders. One man is needed to follow the machine to tamp the soil about the roots, straighten misplaced plants and to plant the gaps. Good results have been obtained with these machines, but a more careful job usually can be done by hand.

COMPANION CROPS

Under intensive cultivation and in home gardens where the greatest possible returns per unit of ground is desired, vegetables are sometimes grown between the strawberry rows during the first season. Most vegetables can be used and the extra cultivation and fertilization given them also will be a benefit to the strawberries. Quick-maturing plants, as lettuce, radishes, and carrots, can be grown between the rows. Onion sets are sometimes grown in the rows. The vegetables should be removed before the strawberry plants begin to send out runners. Companion crops, such as potatoes, beans, and, cabbage, may be set about six inches to one side of the berry rows in the southern regions where the growing season is longer. This system is not adapted to the north because the season is not long enough to mature the vegetables and also allow the strawberry plants to develop sufficiently to bear a full crop the following year. With companion crops, such as potatoes and beans, the strawberry rows are often set four or four and one-half feet apart with the vegetables placed in the center of the cultivated area. In northern districts with a shorter growing season, the mat of strawberry plants must be more narrow than in southern regions when this system of management is used.

Strawberries can be used as an intercrop between rows of fruit trees, but it is good practice to plant only a few rows between the tree rows, and these should not be left longer than two or three years. Adequate space should be left on either side of the tree rows to cultivate with a disk. This is because strawberries are mulched and not cultivated early the second season during a period when young fruit trees need cultivation most. The straw also causes a reduction in available nitrogen to the trees.

CULTURE DURING FIRST SUMMER

Removing flowers. Flower stems should be removed as they appear on the plants the first summer after setting (Figure 274). Otherwise, the flowers will create a severe drain on the vitality of the plants, reducing the number and size of daughter plants and the subsequent crop of berries. The removal of flower stems from varieties which naturally produce a small number of daughter plants will greatly increase the number of runners and plants set.

Thinning and spacing plants. With the hill system of culture, the runners should be cut as soon as they appear, using a sharp hoe or a circular cutter blade (made from blade of crosscut saw) about eight or ten inches in diameter and equipped with an upright handle. Also, considerable hand labor can be saved by equipping the cultivator with two rolling disk cutters attached just far enough apart to cut runners along the outside borders of the rows. This cutter cannot be used, however, in stony land or where there is straw mixed with the soil.

With the spaced-row system of culture (Figure 272), the runners are moved into place and the tips covered with soil as they begin to enlarge. The work must be done by hand. The first daughter plant is placed in the row between the mother plants. The next ones are placed the length of the runner out from the original row on either side. This makes three rows of plants and either all runners thereafter may be removed or additional runners may be rooted until a wide bed has been formed with plants spaced six to twelve inches apart, or as desired. Thereafter, all other runners should be cut. With this system, the plant-spacing and weed-hoeing jobs both can be done at the same time.

With the matted-row system, surplus plants should be removed from the outsides of the rows during late summer or autumn, using a cultivator equipped with a special disk, described above, and by hand hoeing in the row. Some growers run a spike-toothed harrow down the middle of the row in late summer or autumn with the teeth slanting backward so that only the weaker poorly rooted plants are dislodged. The harrow must be carefully tried first, however, to make sure it is not loosening too many plants. Another practice is to run a bull-tongue plow with a four- or five-inch-wide point down the center of the row, tearing up the center plants and dividing the matted row into two parts.

Cultivation. The strawberry field must be kept clean during the first season by frequent cultivation and hoeing to destroy weeds and conserve moisture. Work the soil toward the plants in hoeing and cultivating. Moist soil must be kept around the crowns continuously, but not covering them. Cultivator teeth should be shortened so as to stir only the upper one or two inches of soil. Cultivation should be continued until the first hard frost or until the mulch is applied in regions where it is used. Weeds should not be allowed to start growing in the fall; otherwise, they will give severe competition early the next spring. A field free of weeds the first season will have few if any developing prior to harvest the next season. If weeds are present during the months when the fruits are sizing, they interfere with honeybee movements and proper pollination of the blossoms, causing many "nubbins" to develop. Only a moderate amount of weeds has been known to reduce yield by 1200 quarts per acre.

FERTILIZERS

Before the strawberry plants are set, much can be done to insure high production by placing the soil in the best possible state of fertility. As pointed out earlier, high organic matter content in addition to the fertilizer elements is of paramount importance.

When strawberries follow cultivated crops, they ordinarily do not show response to fertilizers because there is sufficient in the soil left over from fertilization of the previous crops. If the strawberry leaves are dark green and the foliage abundant, no fertilizer should be applied unless trial plots for the particular soil have shown their value. The kind, amount, and time of applying fertilizers vary in different regions with the kind of soil, amount of rainfall, market and transportation conditions, varieties, and other factors.

Strawberries in the North Carolina region respond well to nitrogen application because soils in this region tend to be lower in available nitrogen than those to the north. There are some areas, however, further north along the coast where strawberries respond well to the equivalent of 60 pounds per acre of actual nitrogen in organic or inorganic form, applied about August 15 in Maryland and around September 1 in New Jersey and Virginia. If nitrogen is added where not needed, it tends to cause a vigorous top growth with a decrease in yield and shipping quality of berries. Strawberries on acid soils definitely respond better to nitrate of soda than to ammonium sulfate. This is particularly true in the Atlantic Coast states, whereas in the

Central states more of the soils are near the neutral point and thus response is better to ammonium sulfate.

In the spring of the fruiting year, an application of nitrogen has been found profitable in the growing of certain varieties, especially Fairfax, Marshall, William Belt, and Chesapeake. With most other varieties and on moderately fertile soils, an application of nitrogen at this time will either show little or no response or injure the crop. On poor soils, however, nitrogen application may be worthwhile.

Nitrate of soda shows the best response when applied during the latter part of August. Stable manure may be used in place of, or, in addition to nitrate of soda. If free from weed seed, stable manure can be applied as a strawy mulch to protect the plants from heaving during severe winter weather. The nitrogen, humus, and other elements in manure tend to stimulate leaf growth the following year which aids in supporting a large crop of berries.

The addition of phosphoric acid in the Mississippi Valley region, ranging from 100 to 800 pounds per acre of superphosphate has greatly increased yields. The amount needed for a specific soil can be determined best by small trial plots.

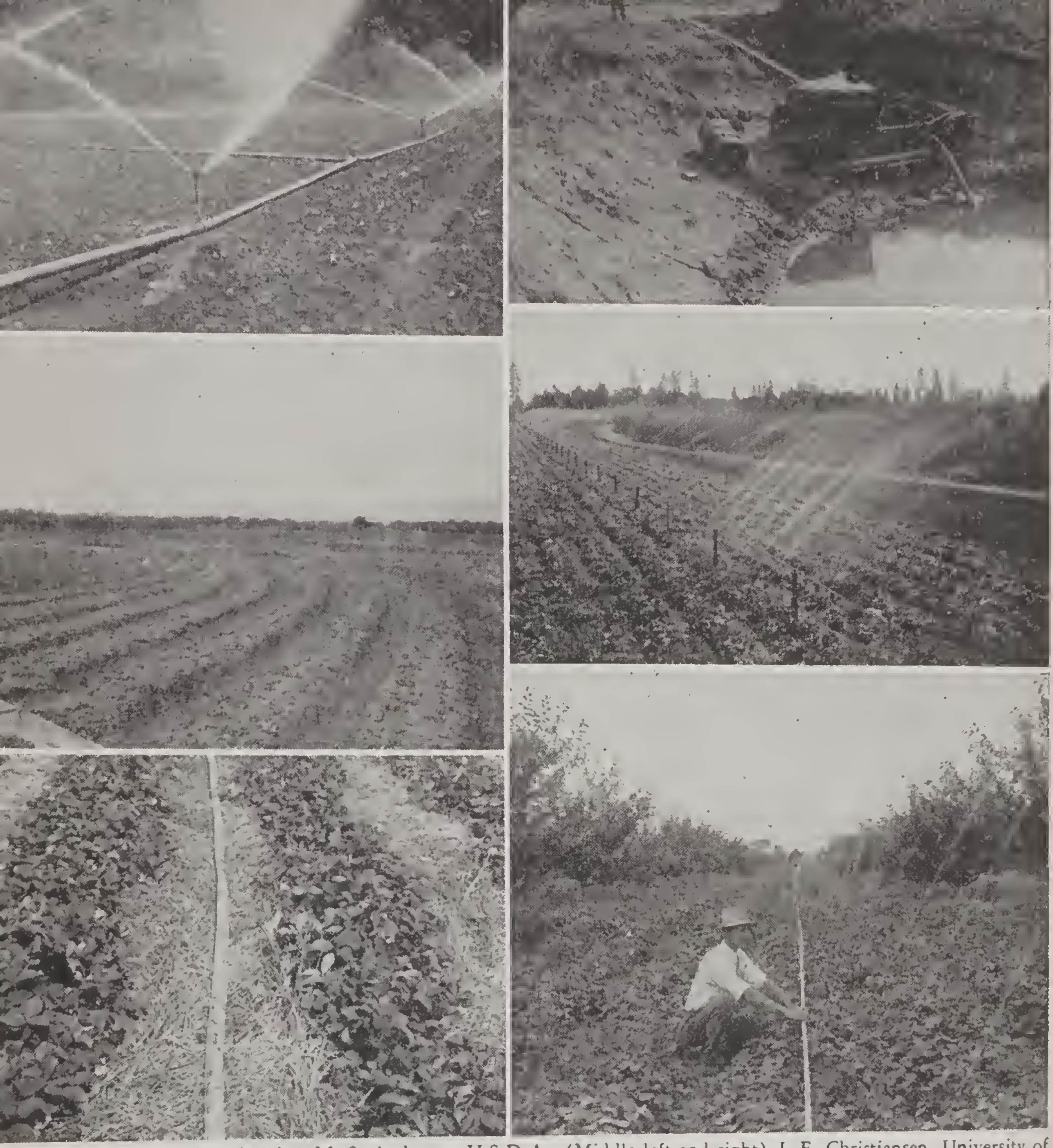
On most soils, potash shows little or no response. Applications range from 50 to 300 pounds per acre of muriate of potash, depending upon response obtained in local test plots.

Soils vary tremendously in fertilizer needs, not only from one region to the next, but from one piece of land to the neighboring piece. Therefore, it is sound practice for a large grower to maintain small test plots to determine the relative value of manure, phosphoric acid, potash, nitrogen, and possibly magnesium and minor elements if his soil is sandy and low in organic matter. Also, the advice of the local state experiment station and the experience of neighboring growers should be carefully considered.

Time to apply. Fertilizers may be applied at three different times: (1) at time of planting, (2) during the first summer, and (3) just before blossoming in the fruiting season. Growers make only application (1) in some regions, whereas in others (1) and (3) are made, or all three.

Potash and phosphoric acid, if needed, may be applied prior to the setting of the plants, but nitrogen should be applied during the latter part of August or the first part of September of the first growing season. Potash and phosphorus may be broadcast or drilled where the plant rows will be located. Later application of these materials and nitrogen either may be scattered on the plants or drilled along the side of the rows. When applied to the plants by hand, which is the common practice, the plants should be dry and later brushed or dragged over to remove the fertilizer from the leaves and prevent foliage burning. If the plantation is being renewed for a second or third fruiting, fertilizer should be applied at the time of renewal in midsummer.

Lime. Lime not only reduces the acidity, but serves as a source of calcium. If dolomitic lime is used, magnesium also is added to the soil. According to Darrow, strawberries grow well on soils having a pH of 5.7 to 6.5. How-



(Top left and right) M. S. Anderson, U.S.D.A. (Middle left and right) J. E. Christiansen, University of California. (Bottom left) Ohio Agr. Exp. Sta. (Bottom right) Dept. of Pomology, Cornell University

Figure 275. Strawberries are shallow rooted and require adequate moisture for high yields. Several systems of irrigation are used. (Top left) A portable, inexpensive, light weight, jiffy-coupling irrigation system with rotating sprinklers. Water is being supplied to system by pump shown in photo at top right. (Middle left) Contour ridges irrigated by the furrow and wooden-flume system, utilizing alleyways. (Middle right) Oscillating-type sprinkling system in California. (Bottom left) Ooze hose on straw mulch in the spring of fruiting year in Ohio. (Bottom right) Temporary sprinkler system installed in young McIntosh orchard in New York.

ever, if the organic matter content is high, they will grow satisfactorily at a wider pH range of 5.0 to 7.0. Lime applied at the rate of 1000 to 2000 pounds per acre on acid soil tends to tie up free aluminum which is particularly toxic to strawberry plants; it also makes calcium and magnesium readily available, and induces better tilth of the soil. The lime should be applied a year or two in advance of planting strawberries. Lime is usually beneficial on the acid soils of the Atlantic Coast states, but not so commonly needed in the Mississippi Valley and the Pacific Coast states.

IRRIGATION

In regions where droughts frequently occur during the early part of the season and at harvest time, some kind of irrigation should be provided. Lack of proper water supply is probably responsible for more low yields and failures in strawberry growing than almost any other factor. Also, it is usually in drought years when an irrigation system pays well, because of local or widespread shortage of berries. Under irrigation, strawberries must be grown intensively because the cost of installing an irrigation system is such that the grower must make every square foot of ground count to make the enterprise financially successful. An irrigation system is a permanent improvement on a farm, but it should not be installed until the grower is assured that adequate local labor will be available. An abundant water supply must be available for an irrigation plant from either a well or a stream that does not run dry during severe droughts.

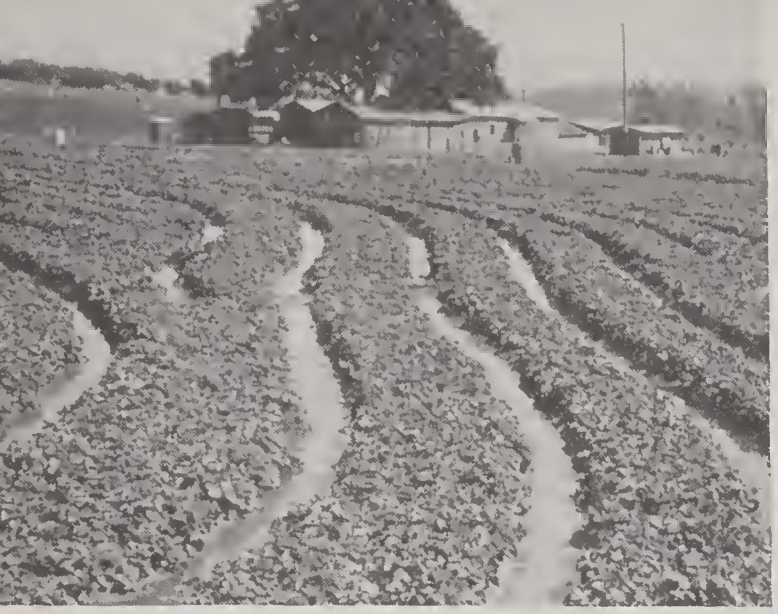
Overhead systems. The overhead sprinkling or spray systems, as commonly used in southern New Jersey and sparsely employed throughout the eastern states, have been found profitable in practically all instances. The investment in these systems, depending upon materials used, may vary from $80 to $400 or more per acre. The portable-pipe irrigation systems with whirling sprinkler heads and jiffy couplings, shown in Figure 275, involve less investment per acre, running as low as $35 in normal times. The overhead spray irrigation system, shown in Figure 275, has been responsible for 8000-quart yields per acre of Chesapeake in years when only 3000 quarts were obtained from this variety in neighboring fields without irrigation. Some varieties such as Chesapeake respond particularly well to irrigation.

Surface irrigation. Furrow irrigation can be used only where the soil, or particularly the subsoil, is heavy and where the slopes are uniform and gentle (Figure 276). Irrigation furrows 200 to 250 feet long are frequently used in commercial plantations. Shallow furrows are made in the alleyways during the first season and in alternate alleyways during the harvest season to facilitate the harvesting.

On sandy soils or irregular land, either the porous hose (Figure 275) or eyelet hose is well adapted. The porous, or ooze hose will irrigate only one row at a time, whereas the eyelet hose with holes spaced about two feet apart will irrigate three or four rows at one placement.

WINTER PROTECTION

The strawberry leaves become hardened with the cooler temperatures in early fall and can often withstand a temperature of 15° F. without injury in late fall or early winter. If the temperature falls to 0° F. or below during



U.S. Soil Conservation Service

Figure 276. A strawberry field in Santa Cruz County, California, under irrigation by contour furrows between beds.

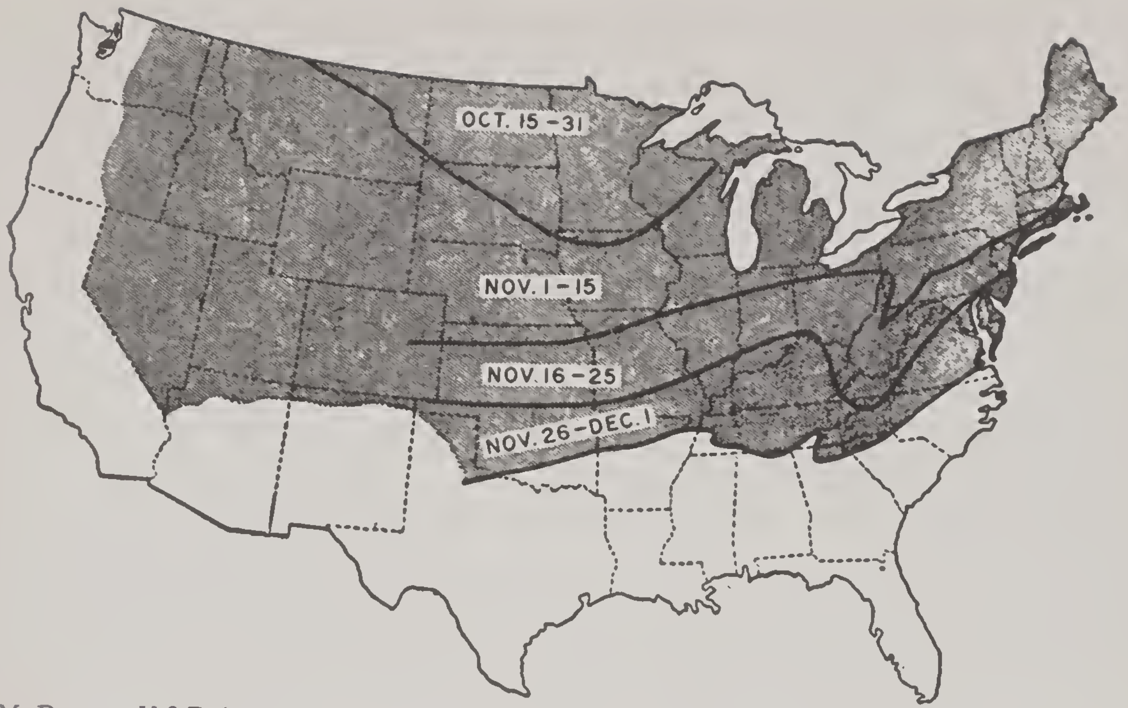
the winter with no blanket of snow over the plants, they may be severely damaged. Also, alternate freezing and thawing of the soil, especially the heavier soils, will heave the plants out of the soil, causing severe damage or death by the beginning of the next growing season. The use of mulch is effective in minimizing this injury. Mulching also has the advantages of smothering weeds, keeping the berries clean, and conserving moisture. In the South, the primary purpose of mulching is to conserve moisture and keep the berries clean, and not for cold protection. Little or no mulching is practiced in the West.

Mulching with marsh hay, wheat or other straws, or pine needles and ferns is recommended on the dates shown in Figure 277 for the respective regions. In the upper Mississippi Valley region, about six tons of straw per acre should provide sufficient protection. In the rest of the country where mulch is needed, two to two and one-half tons per acre are sufficient. The straw should be as free from weed seed as possible. If straw is scarce, Sudan grass can be raised for mulching material; but it should be cut before becoming coarse. Oats may be sown thickly in the alleys at the rate of one and one-half to two bushels per acre. Oats kill down in early winter and help furnish a thin mulch.

When growth starts in spring, surplus mulch should be pulled from the tops of the plants and placed in the alleyways. A light covering of straw can be left on the plants since they can come through readily. Mulch may delay ripening by a few days to a week, depending upon the thickness of the mulch on the plants.

If an unseasonable spring frost is expected, it may be advisable to pull the straw from the alleyways back over the plants again. While this involves extra labor cost, it frequently proves profitable. If an overhead irrigation system is available, plants can be sprayed late in the evening prior to the night a frost is expected and the spraying continued until the next morning. This will hold the temperature of the leaves and flowers around 32° F. and protect them for the most part from frost injury. Smudge pots or heaters are sometimes used, 100 per acre, to protect the plants when the temperature drops to 6° or 8° below the freezing point at the ground level. Where fires are used to protect the berries, many small fires should be maintained throughout the strawberry field, or at the lower side if it is on a slope.

If the region is particularly susceptible to frost injury, everbearing varieties might better be used, and if the first crop of blossoms is killed, another set



G. M. Darrow, U.S.D.A.

Figure 277. Map showing areas in which cold injury to strawberry plants may be expected often enough to make mulching pay. Growers in each area should be ready to put on the mulch by the first date listed and should have applied the mulch by the latter date.

of flowers will appear provided conditions are favorable. Also, the use of late-blooming varieties should be considered in frost-susceptible regions.

RENEWING THE PLANTATION

The number of crops harvested from a strawberry field varies in different sections of the country from only one crop to two, three, or even more crops before the plantation is plowed under. The number of crops that can be harvested depends upon the variety, the amount of weeds in the field, infestation of insects and diseases, character of the soil, and the cost of renewing an old plantation as compared with the cost of setting a new one.

Some varieties yield only one big crop, while others may yield a larger crop the second and third years. For the latter varieties, the plantation should be continued for at least two years. Aroma may yield good crops for several years.

If the field is heavily infested with weeds such as white clover, purslane, chick weed, and crab grass, it may be necessary to harvest only one crop and plow up the field. White clover is difficult to eradicate once started; it is usually easier to start a new plantation than attempt to combat it.

If humus content of the soil is low, only one crop may be profitable. With such soils, it is best in the long run to turn under green manure crops or apply stable manure before setting the strawberries in order that the plantation will be profitable for more than one year.

If intensive cultivation is practiced, the plantation should probably be kept for at least three crops, and sometimes for five or six crops, or as long as it gives profitable returns. Cost of renewing the plantation is undoubtedly less than the cost of setting a new field.

Mowing the plantation. Plants trained to the matted-row system can be mowed over with the sickle bar on the mowing machine set low. Plants under the hill system are best cut with a sickle, scythe, or sharp hoe. In the northern states where the growing season is short, the foliage should be mowed as soon as harvesting is finished. In the region of Maryland, this is before July 1. Where the growing season is longer, mowing can be delayed for a few weeks. If the straw mulch is thin and there is little insect and disease injury to the strawberry plants, the mulch and strawberry tops should be turned under to increase the humus content of the soil. If mulch is heavy, part of it should be removed and stacked for later use if it is in good condition.

If insects and leaf spot diseases are prevalent, a common practice is to burn the foliage and mulch on the field which afterward facilitates thinning the plants and narrowing the rows. The mulch is raked on top of the rows and when a good breeze is blowing with the direction of the rows, a fire is started on the windward side. Leaves and straw should be dry and the ground somewhat moist so that the field will burn over rapidly with little or no injury to the plants. Crowns of some varieties, such as Dunlap, are tender to burning and the above over-all treatment should be done only after trying a small area. If the variety is tender to this treatment, the mulch should be pulled into the alleyways for burning.

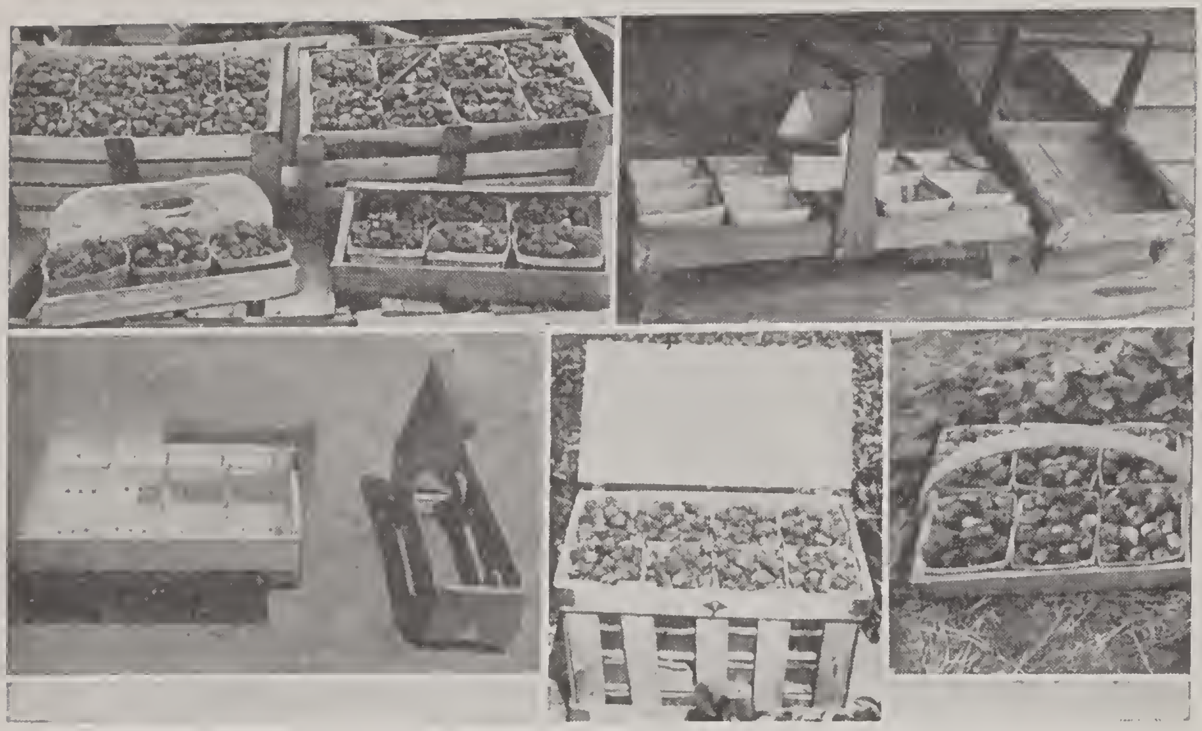
Thinning the plants. In renewing the matted-row plantation, the old plants must be thinned out, leaving only young plants. The middle and one entire side of the matted row should be plowed up, leaving the young plants on the other side. If the variety is a prolific plant producer, the row should be reduced to six to eight inches in width and the plants in this row thinned to at least ten inches apart. If the variety is a poor plant producer in late summer, leave the row 12 to 15 inches wide and thin the plants to ten inches apart.

The plants left in the matted row can be thinned by dragging a spring-tooth harrow or a cultivator across the rows once or twice and then once down the row. If the plants are still too thick, they can be further thinned with hoes. Within two or three weeks after this treatment, new foliage will have appeared and the field should resemble a young plantation.

Where the narrow matted-row system has been used, the width of the row may not need to be reduced. A shovel cultivator can be used to plow across the rows, leaving the clumps of plants about 24 inches apart. The runners can be trained into the spaces later in the summer to form continuous matted rows by winter.

HARVESTING AND SHIPPING

Varieties with soft flesh should be picked before fully ripe in order that they arrive at the market in good condition. Firm-fruited varieties can be



(Bottom left) California Agr. Exp. Sta., (Others) G. M. Darrow, U.S.D.A.

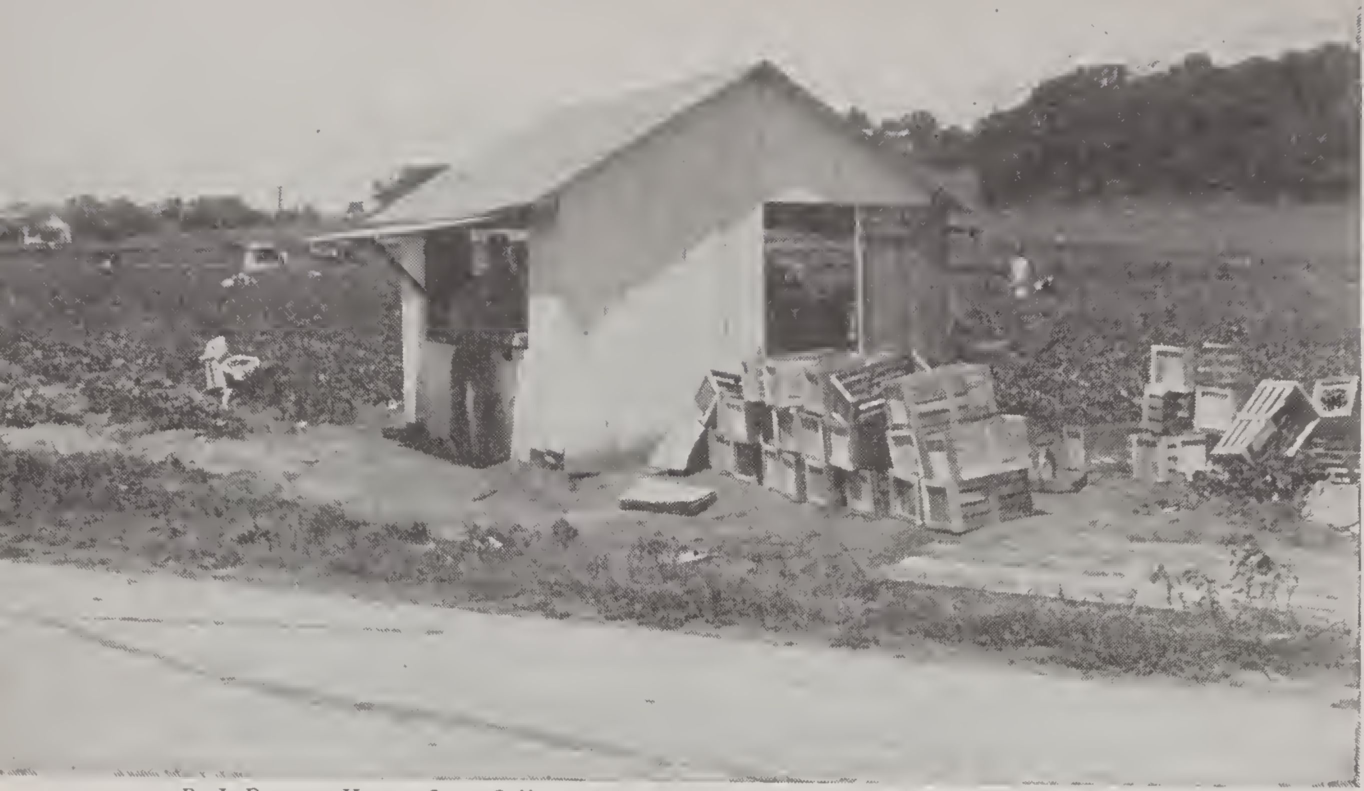
Figure 278. Picking baskets and shipping containers. (Top left) These shipping crates hold 24-quart baskets each, are cheaply constructed, and often called "gift crates" because they usually are not returned to the shipper. Two types of picking carriers are shown in front. (Top right) Two 10-quart large picking carriers. (Bottom left) Wheeled-crate carrier is pushed ahead of the picker. (Bottom middle) A 32-quart crate equipped with hinged lid, and usually returned to shipper. (Bottom right) A lightweight 6-quart carrier in common use for picking berries.

left on the plants until ripe; they will have a better appearance on the market than those picked partly green. Some varieties, such as Howard 17 and Fairfax, can be picked over a period of four weeks or longer, whereas varieties such as Gandy have a short picking season of 10 to 14 days. It is necessary that the grower take these varietal characteristics into consideration in planning his work program. Some varieties may need to be picked every day, whereas others will need picking every two or three days. More pickings are necessary during hot weather than during cloudy weather.

No ripe berries should be left at each picking, nor should partially rotted berries be included in the basket. One bad berry may cause the loss of one basket or an entire 32-quart crate.

Some varieties are more difficult to pick than others, depending upon the growth habits of foliage and exposure of berries. Pinch off each berry, leaving about one-half-inch of the stem attached to the berry. Exert pressure on the stem only, and none on the berry flesh. Place each berry in the basket carefully (not thrown or dropped). Berries picked in the early morning keep longer and look better than those picked at the hot noon hour. Picked berries should be placed in the shade as soon as possible. For each 15° F. rise in temperature, the life of the berry is decreased by one-half.

Field carriers used for picking the berries are shown in Figure 278. A six-quart carrier is used for picking and a ten- to twelve-quart carrier is used for transferring the berries to the packing house. If the packing shed, shown in Figure 279 is close by, the larger carriers are unnecessary.



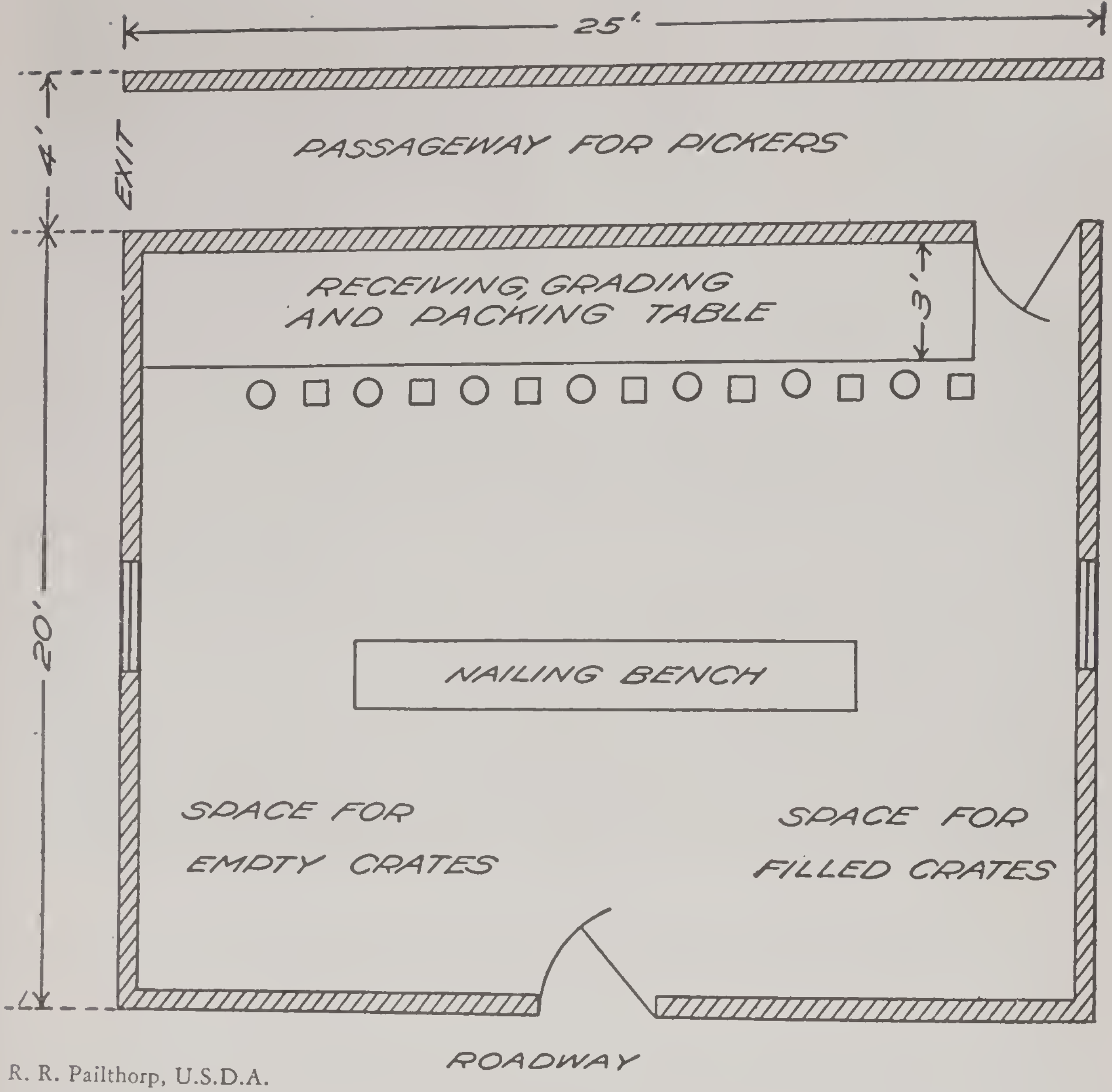
R. J. Barnett, Kansas State College of Agr.

Figure 279. Strawberry sheds in the foreground and background are for receiving, sorting, and packing strawberries for shipment. Some direct sales are made at the main highway in the foreground.

In normal times, pickers are paid one to two cents per quart for gathering berries, although the wage differs with region, grade of work, and plan of management. For example, in one district pickers may be paid six cents a gallon and if by good behavior they may remain until the end of the season, they are given another cent or two for each gallon picked during the entire season. This serves to hold pickers through the latter part of the season when berries run smaller and less plentiful. Another system is to pay the best pickers one-half cent a quart more than untrained or poor pickers. The extra pay encourages careful work; also, berries are usually worth more when handled by good pickers.

Two pickers per acre are sufficient where yields are small; eight or ten are sometimes needed at the height of the season on the better fields. A field yielding 124 24-quart crates an acre can be covered by four pickers working every day. Almost all of the berries should be of best market grade if the plants have been properly spaced in the rows, if the field is free from weeds and grass, and if the humus in the soil is high and the mulch is sufficient to maintain even moisture while the berries are developing and ripening. These practices not only increase yields of high-quality berries, but also reduce considerably the loss in time and labor in handling poor-quality low-value berries at harvest.

Crates and carriers. In the southern states, a 24-quart crate or the 24-pint crate, nonreturnable, is commonly used for shipping berries north. A "pony" refrigerator box holding 32, 64, or 80 quarts of berries with a metal tray at the top or center filled with ice is used for expressing strawberries from Florida to northern states. However, this transportation system, and that by



R. R. Pailthorp, U.S.D.A.

Figure 280. Simple floor plan for a strawberry receiving and packing shed.

trucks and trains may be displaced to some extent in the future by air express. The present rapid growth of air transportation with further reduced rates may make it possible to harvest ripe berries in the South one day and have them on the northern markets the next day (Figures 281, 282).

Cold storage. Strawberries can be held in storage a maximum of about ten days, even though the temperature is held at 32° F. After this period, the fruit begins to lose its fresh bright color, shows some shriveling and deteriorates in flavor. At temperatures of 40° or above, loss from gray mold rot, rhizopus rot, and leather rot may become serious.

Frozen pack. Certain varieties of strawberries freeze as good or better than almost any other fruit. In Washington and Oregon, over 85 per cent of the berries grown are preserved by the frozen-pack method. This method of preservation is also being used widely in Louisiana and other commercially important southern states. The importance of this method of preserving strawberries can be realized from the fact that the average storage holding of frozen strawberries on January 1 for the years 1940–44 was 37,072,000 pounds. Freezing of strawberries has been discussed in Chapter XIX.

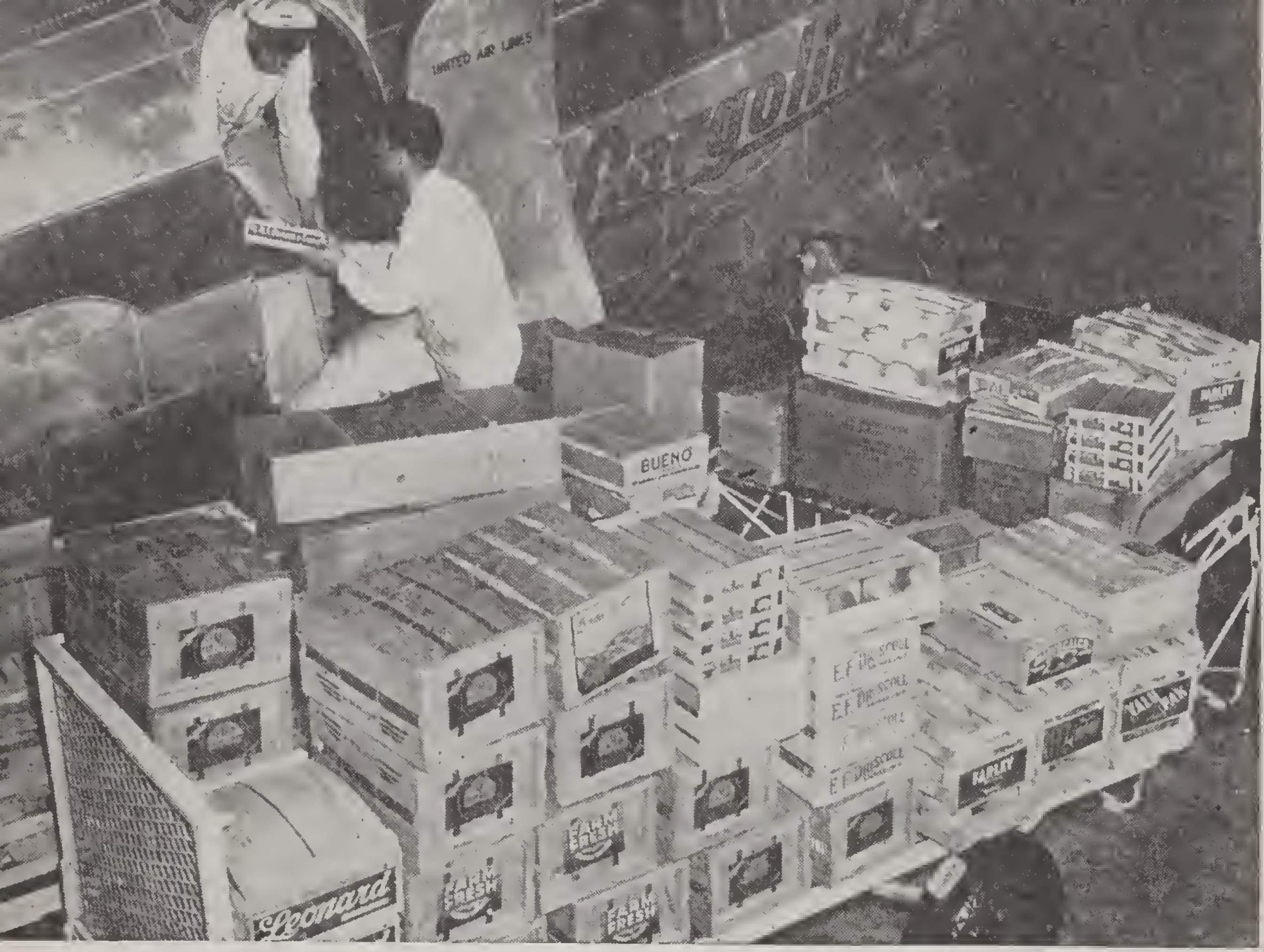

United Airlines

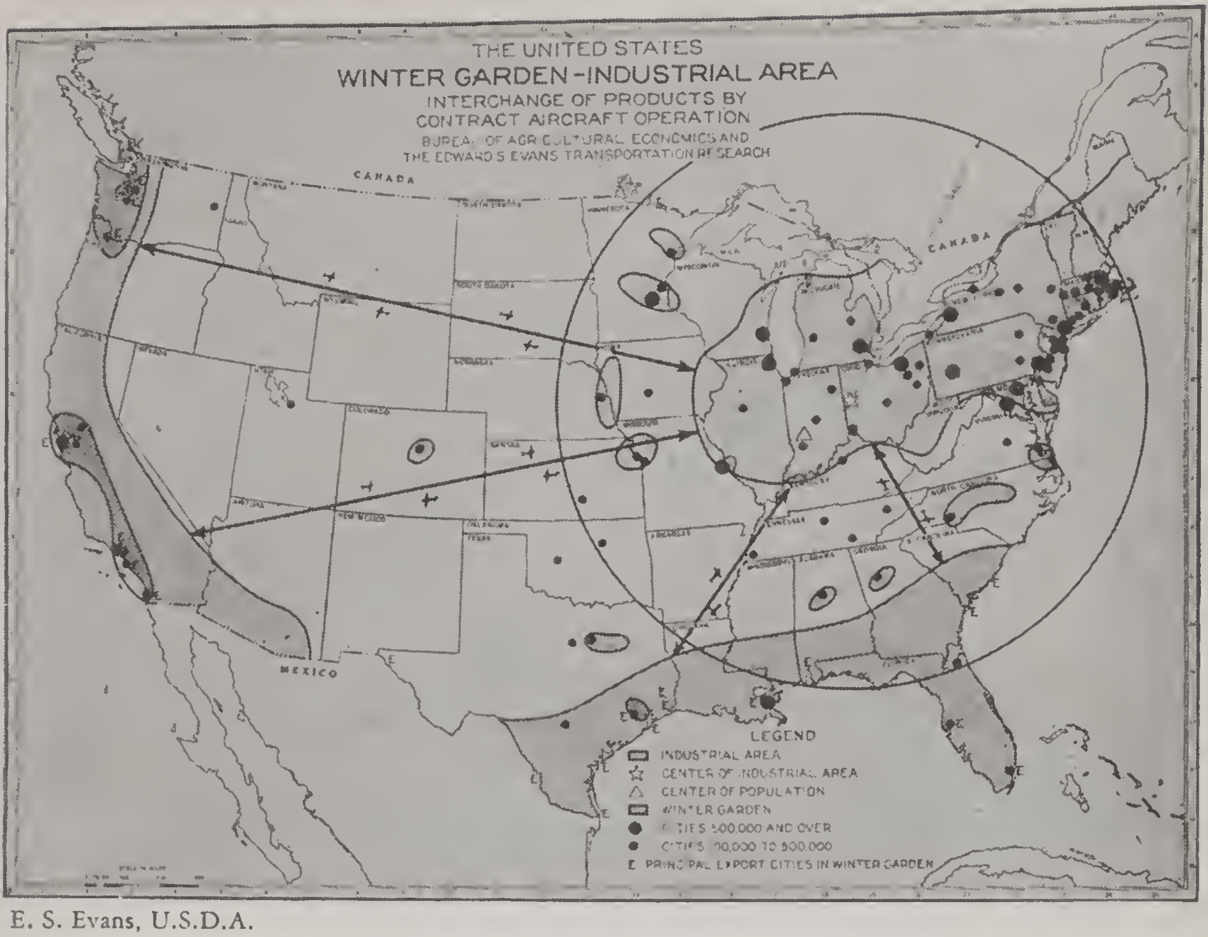
Figure 281. Shipment of fresh strawberries and other fruits by airplane is on the increase. Firm-ripe berries from the South can be placed on northern markets the day after picked, thus reducing the early picked green berries often appearing on northern markets.

Yields. Factors which influence yield are the general vigor of the plantation, the variety, the season including possible losses from frost injury at blossoming time, and distribution of rainfall. Many of the better growers secure 5000 to 6000 quarts per acre regularly with occasional higher yields reaching 8000 and 9000, particularly when grown under irrigation. The net profit from 3200 quarts per acre is doubtful in the northeastern states, whereas in other regions with cheaper labor costs, a small profit may be realized from this yield.

DISEASES

With strawberries it is possible to rotate the ground frequently and consequently, diseases and insects are not likely to become as serious a problem as where the fruit crop occupies the ground for many years. The following diseases (see also Figure 284) are among the most common. For more specific control measures, the reader is referred to his local agricultural experiment station and to a special bulletin by Demaree.

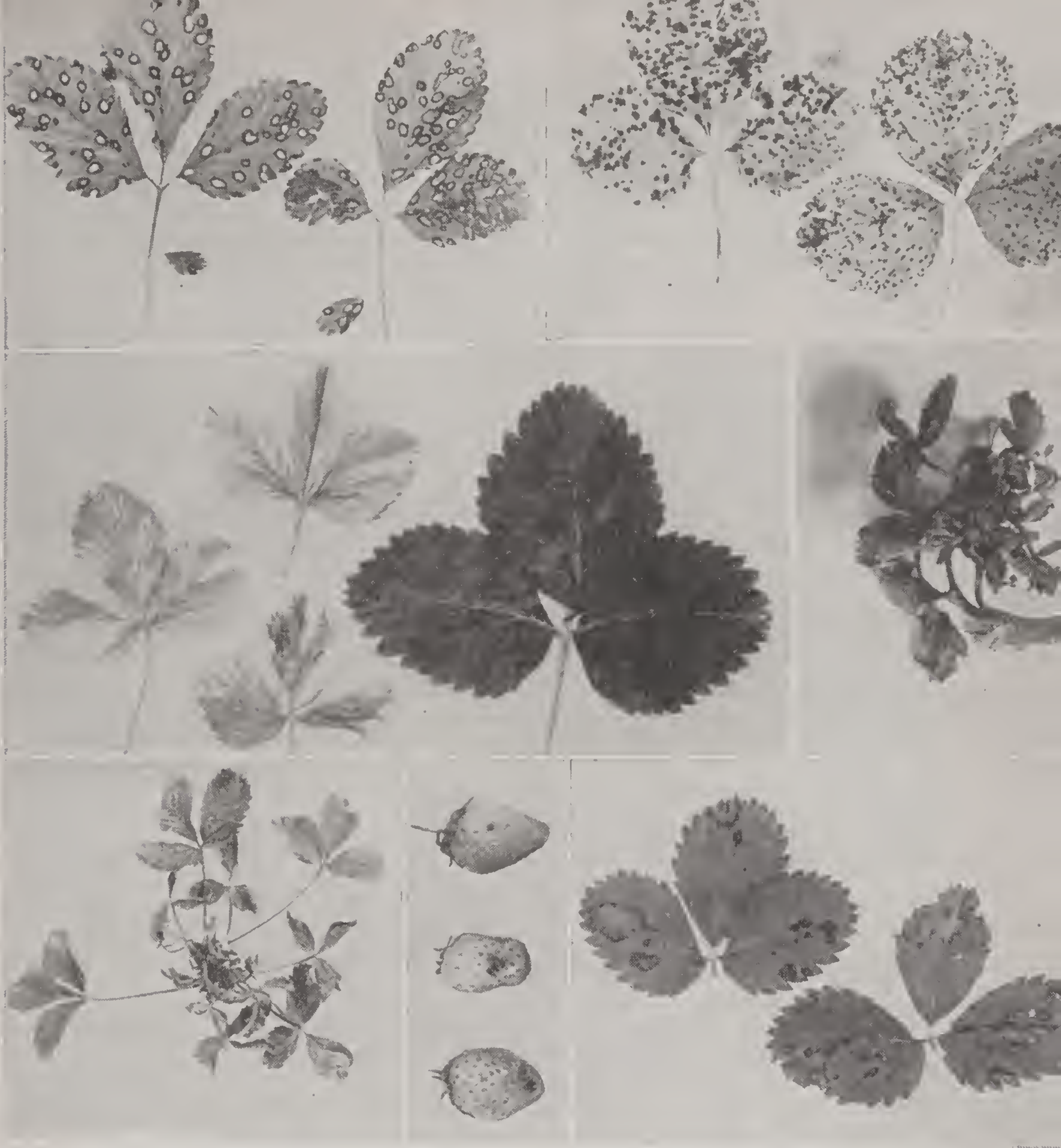
Leaf spot (*Mycosphaerella fragariae*) occurs in almost all regions where strawberries are grown, particularly in some Gulf-state regions. Varieties vary in susceptibility; Howard 17 is very resistant. A 4–4–50 Bordeaux mix-


THE UNITED STATES
WINTER GARDEN-INDUSTRIAL AREA
INTERCHANGE OF PRODUCTS BY
CONTRACT AIRCRAFT OPERATION
BUREAU OF AGRICULTURAL ECONOMICS AND
THE EDWARD S EVANS TRANSPORTATION RESEARCH
CANADA
CANADA
MEXICO
LEGEND
INDUSTRIAL AREA
CENTER OF INDUSTRIAL AREA
CENTER OF POPULATION
WINTER GARDEN
CITIES 500,000 AND OVER
CITIES 100,000 TO 500,000
E PRINCIPAL EXPORT CITIES IN WINTER GARDEN

E. S. Evans, U.S.D.A.

Figure 282. This map shows winter garden production area which supplies by air the heavily populated industrial areas in the East.

ture applied in as many as six applications at ten-day intervals is considered a profitable practice in Louisiana. The spray should be applied well in advance of the harvest season to be effective. Bordeaux also controls *leaf scorch* (*Diplocarpon earliana*), consisting of dark purplish spots about one-quarter inch in diameter without the white centers, as found in case of leaf spot (Figure 284). *Leaf blight* (*Dendrophoma obscurans*) is characterized by large red to brown spots surrounded by purplish margins; it occurs largely on old fruited plants, not young ones. Remedies are not warranted. *Crinkle,* a virus disease, is commonly found in Pacific Coast states, occasionally in the East. Leaves may be distorted, wrinkled, lighter shade of green, petioles short with leaves lying flat on the ground, giving the plants a dwarfed appearance. Use state-inspected stock, plant on isolated fields away from crops harboring aphids (the vectors), and rogue-infected plants early. *Yellow* (*Xanthosis*), a virus transmitted by strawberry aphis, is prevalent from Puget Sound to southern California and is frequently present in the East. Affected plants are dwarfed and somewhat yellow, occurring in strips in a row. Leaves may be cupped with less point at the tips, and showing dull green centers with yellow edges. See control for crinkle virus. *June yellows* is due to a hereditary factor. Leaves show mottling and streaking with yellow and green. The markings differ with the variety and season. Blakemore and Howard 17 are susceptible. Allied species of *nematodes* are respon-



J. B. Demaree, U.S.D.A.

Figure 284. Strawberry diseases include (top left) leaf spot; (top right) leaf scorch; (middle left) noninfectious leaf varigation or June Yellows; (middle right) spring dwarf caused by a nematode; (bottom left) summer dwarf caused by a nematode; (bottom middle) black-seed disease caused by strawberry leaf spot fungus; and (bottom right) strawberry leaf blight.

sible for a summer dwarf appearing in the South during high summer temperatures, and for a spring dwarf appearing early in the season. Control is by rigid state inspection of nursery plants. *Red stele* root disease is caused by a fungus occurring largely in the northeastern states, resulting in stunting and dwarfing in spring and wilting and dying of older leaves. Fungus invades central cylinder (stele) of root, causing it to turn dark red with outer

(Top) T. J. Talbert, Missouri Agr. Exp. Sta. (Bottom) J. F. Cooper, Florida Agr. Exp. Sta.

Figure 283. (Top) Shipping point inspection of strawberries by state officials before loading into railway refrigerator cars. This service protects growers and shippers. (Bottom) Shipping strawberry crates by refrigerated trailer truck from Florida to northern markets.

part of root appearing healthy. Disease is aggravated by cold wet soils. Varieties differ in susceptibility; Aberdeen and Temple are outstandingly resistant, while Pathfinder is usually resistant. Nursery inspection is the recommended control. *Blackseed fungus* (*Mycosthaerella fragariae*) causes black spots around one or a few seeds on a fruit, marring appearance. Use spray schedule for leaf spot.

INSECTS

White grubs (*Phyllophaga* or *Lachnosterna*) may cause considerable trouble by feeding on the strawberry roots, as discussed previously. *Leaf roller* (*Ancylis competana fragariae*) larvae roll the leaves after feeding for a short time in the spring and continue to feed from within the enclosed chamber; serious losses sometimes occur. Application of two pounds of arsenate of lead in 50 gallons of water is suggested in early spring before larvae fold leaves. *Strawberry weevil* (*Anthonomus signatus*) lays eggs in flower buds and then girdles the stem. Larvae feed in buds, destroying them. Injury may become serious in some regions. Strawberry varieties having imperfect flowers are free from injury. Dusting the vines with a mixture of one part of arsenate of lead to five parts of sulfur as the beetles begin to damage the buds is effective control. The *Cyclamen Mite* (*Tarsonemus pellidus*) occurs widely in the northern states and Canada, causing dwarfing and, in severe cases, loss of entire crop. Nursery planting stock treated for mites is available. New plantings should be made some distance from old infested fields. The *Spittle bug* (*Philaenus leucophthalmus*) frequently found in Oregon and Washington, is controlled by dusting with rotenone.

EVERBEARING STRAWBERRIES

Everbearing varieties of strawberry bear fruit at the usual time followed by a period of little or no production until late August when another crop is harvested throughout the fall if growing conditions are favorable. Everbearing varieties, principally Mastodon, with Progressive (Champion) of lesser importance, are valuable in the valleys of western states such as Idaho where late spring frosts frequently kill the blossoms of most standard varieties. They are used in the home garden in sections of the United States north of North New Jersey and in the higher Appalachian range. The present varieties are not adapted to the South. Everbearing strawberries are not considered profitable for the general market.

Best berries are obtained in the fall following the spring planting and many fields are kept only for one season. Deblossoming should be discontinued about the first part of July to obtain a fall crop the first year. If the bed is kept a second season, the fruit is borne at the normal time, followed by a rest period and then by further bearing, but the fruit may be small both in size and yield. Everbearing varieties need a very fertile soil and adequate soil moisture in order to develop berry size and satisfactory yields. They may be planted by the matted-row or hill system, depending upon the runner-forming habit of the variety. The culture, otherwise, is similar to that recommended for standard varieties.

Review Questions

1. Give 5 leading states in commercial strawberry production in the United States.
2. Why is it possible to grow strawberries under so widely differing soil and climatic conditions?
3. Describe a desirable location and site for a large commercial strawberry plantation in your region.
4. What factors are paramount in selecting a strawberry variety for local market? For distant market?
5. What is the difference between and significance of perfect and imperfect strawberry flowers?
6. Describe preparations necessary for growing strawberries on land which has been in sod.
7. Why is early planting of strawberries in the upper eastern states so important?
8. Describe briefly, by diagram if necessary, how the hill system of training strawberries differs from the spaced-row and matted-row systems.
9. What is the proper depth for setting strawberry plants?
10. Describe a desirable cultivation and fertilization program for strawberries during the first season in your locality.
11. Of what value is lime in strawberry culture?
12. In almost all regions where strawberries are grown, irrigation is frequently the deciding factor in successful strawberry production. Why is this true?
13. In mulching strawberries in your region, if practiced, what materials can be used, when are they applied, and why?
14. What factors must be considered in time of harvest of strawberries?
15. What instructions would you give your picking crew to reduce damage to the fruits as much as possible?
16. List an important insect and disease of strawberries in your region.
17. Under what conditions should a strawberry plantation be renewed?
18. Give briefly the steps for renewing a plantation trained to the matted-row system.

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CHAPTER XXII

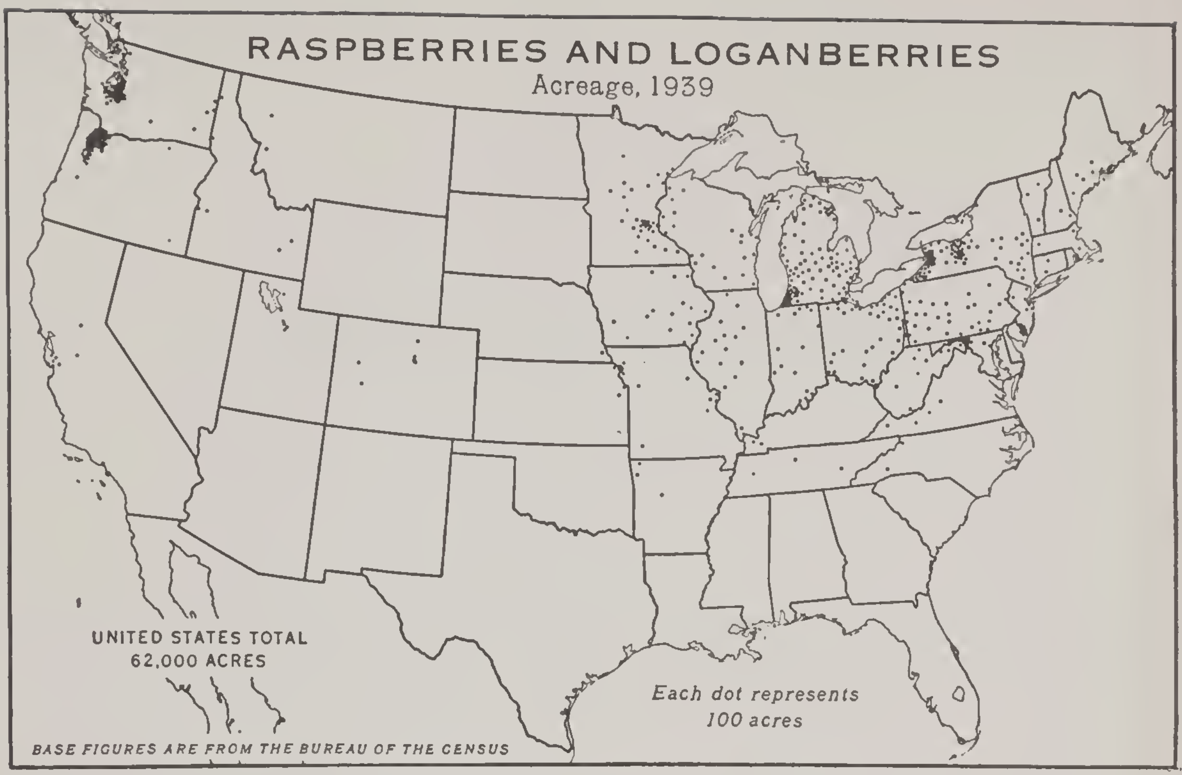
Bush Berry Culture

Included among the bush berry fruits of commercial importance are the brambles, gooseberry, currant, and blueberry. The blueberry has shown a marked increase in popularity in recent years, but it, like the cranberry, is of commercial importance only in a few localized areas in the United States. The cranberry also is briefly discussed in this chapter, but actually, it is too prostrate to be considered as a bush fruit in the strict sense of the term.

THE BRAMBLES

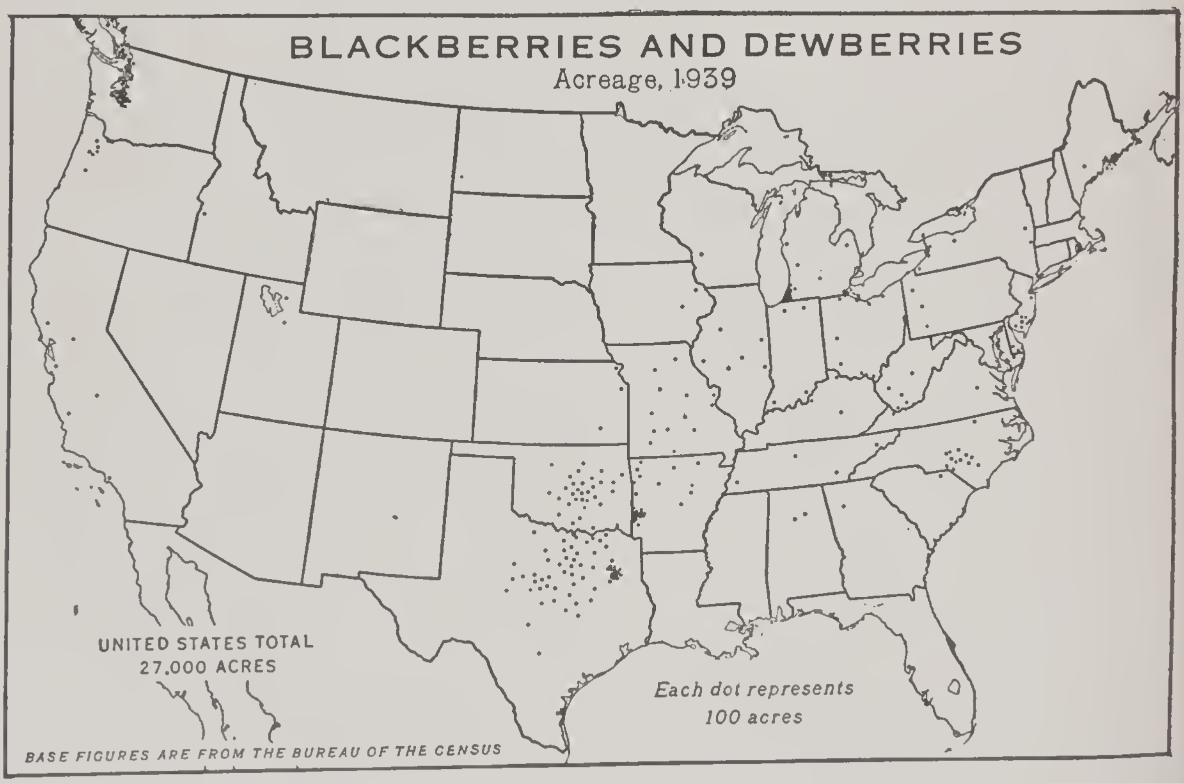
The brambles include the raspberry (red, black, and purple varieties), blackberry, dewberry, and their hybrids and sports. The brambles differ somewhat in climatic requirements. Where one succeeds, the other may produce poorly or not at all. Thus, more than half of the raspberry acreage in the United States, according to the 1945 Census, is confined to four northern states; namely, Michigan, 11,279 acres; New York, 7,914; Washington, 4,765, and Oregon, 4,374 (see Figure 285). Raspberry acreage in the South is limited to the high cool elevations. The loganberry, probably a red-fruited sport of the wild blackberry, is confined more or less to the Pacific Coast where more than two-thirds of the acreage is located in the Willamette Valley of Oregon. Most loganberries are canned or crushed into juice, whereas raspberries are largely used fresh and frozen in the regions where grown.

Blackberries can withstand more heat and dryness than raspberries and hence, as shown in Figure 286, about half of the acreage is located in three southern states; namely, Texas, 4,828 acres; Oklahoma, 3,346; and Arkansas, 2,575 (figures based on 1945 census). A limited acreage of blackberries is found in Washington and on a line from Maine to Missouri. Leading commercial dewberry sections are Berrien County, Michigan; the Hudson River Valley of New York; and North Carolina.


RASPBERRIES AND LOGANBERRIES
Acreage, 1939
UNITED STATES TOTAL
62,000 ACRES
Each dot represents
100 acres
BASE FIGURES ARE FROM THE BUREAU OF THE CENSUS

U.S.D.A. Bureau of Agricultural Economics

Figure 285. Raspberries thrive better in the upper-cool states. Michigan, New York, Oregan, and Washingtan lead. Loganberries are grawn in the West, principally the Willamette Valley of Oregon.

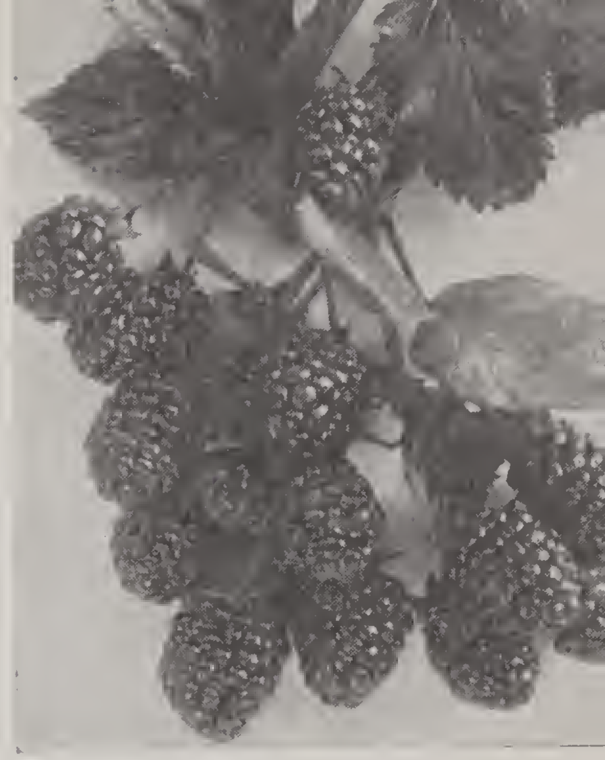

BLACKBERRIES AND DEWBERRIES
Acreage, 1939
UNITED STATES TOTAL
27,000 ACRES
Each dot represents
100 acres
BASE FIGURES ARE FROM THE BUREAU OF THE CENSUS

U.S.D.A. Bureau of Agricultural Economics

Figure 286. Blackberries are grown in a warmer climate than raspberries. Leading states are Texas, Oklahama, and Arkansas. Leading areas far dewberry production are Berrien County, Michigan; Hudson River Valley, New York; and North Carolina.

The red raspberry produces fruit on leafy shoots of erect slender canes. It is propagated by suckers which arise from the roots of the parent canes. Typical red varieties are Latham, Cuthbert, and Ranere. The yellow- and white-fruited raspberries are variants of the red type and are occasionally seen in home gardens. Golden Queen is a common yellow variety.

The black raspberry, often called "blackcap," bears black and somewhat more seedy and aromatic fruit than the red raspberry. Canes of the black raspberry, as contrasted with the red, become arched in late summer and take root at the tips. These rooted tips can be cut away from the parent plant and used for propagation material. Black raspberries in general are not as hardy as some red raspberries and, hence, cannot be grown as far north. Common varieties of blackcaps are Cumberland, Farmer, and Munger.



I. G. Ilgenfritz' Sons Co., Monroe Mich.

Figure 287. Eldorado blackberry is leading variety in the East. Fruit ripens after raspberries.

Purple-fruited raspberries are hybrids between the red and black sorts. They are more vigorous and productive than either of the parents, but resemble the black raspberry in growth habit and in method of propagation. Leading varieties are Columbian, Potomac, and Sodus.

Blackberries grow wild in most sections of the country and this has impeded to some extent the cultivation of the improved varieties which have firmer and better-keeping fruit than the wild sorts. Also, the season of cultivated varieties starts earlier and ends later than for the wild varieties. Eldorado is the leading variety (Figure 287).

The dewberry generally has a prostrate growth habit, whereas the blackberry is upright. Actually, however, all commercial dewberry varieties are crosses between the dewberry and blackberry. Thus, as one would expect, some hybrid varieties are semierect, as the Himalaya, Brainerd, and Evergreen (Black Diamond) blackberries. Lucretia is the popular dewberry for the North. The Young variety, as well as the Boysen are widely grown in the West and South.

Bramble culture in the United States is limited to rather definite regions due to sensitiveness to extremes of heat, cold, and excess or deficiencies of moisture. One should determine from the accompanying figures, the foregoing discussion, and his neighbor's experience, which of the brambles is most likely to succeed in his locality. Most commercial growers rarely plant more than five to ten acres, usually less than five. Fresh sales are more or less limited to local towns and cities, but in larger producing areas considerable quantities may be preserved by the frozen-pack method and canning.

Due to the fact that the fruit is soft and highly perishable, the crop must be either disposed of quickly in the fresh state or preserved.

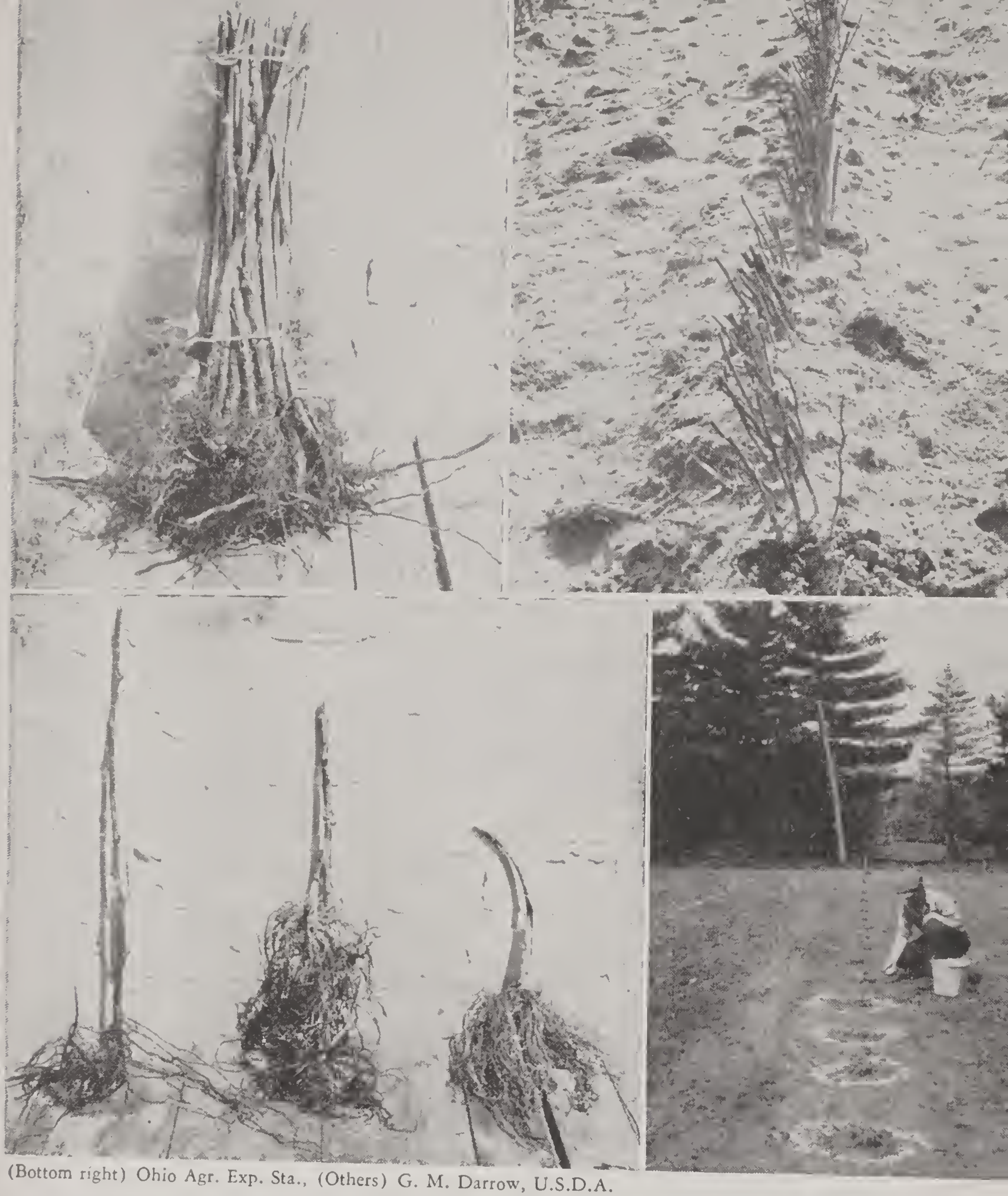
Selecting the site and soil. Good air drainage is important in reducing danger from spring frosts, winter injury, and diseases in regions where troublesome. A northern slope is not necessary but preferred, because the brambles naturally respond well to cool areas somewhat protected from the hot sun. Areas subjected to heavy drifting of snow are undesirable due to breakage of the canes, although some snow cover will help to protect the canes from winter injury. Brambles will grow on a wide range of soils from coarse sand to heavy clay, provided they are well drained to a depth of at least three feet, preferably deeper. It has been shown that the leaves of brambles lose moisture more rapidly than those of most fruit plants, and, thus, provision for adequate soil moisture throughout the season is one of the most important factors in successful bramble culture. The incorporation of organic matter to help attain this desirable moisture situation, as recommended for the strawberry in the previous chapter, is most important. In general, the red, black, and purple raspberries and the blackberry perform best on medium loams, while the dewberry prefers the light soils. The red raspberry will often produce satisfactorily on the heavier soils provided they are well drained.

Planting time. Best results are generally obtained by early spring planting. Fall planting for some brambles is practiced in the southern areas, but the plants should be protected during the winter by mounding with soil. On the Pacific Coast they should be set during the rainy season when conditions permit.

Propagation. The best and safest source of planting stock is from reliable nurserymen who sell inspected certified plants, particularly free from the destructive virus diseases. Stock obtained from old plantations or neighboring growers should be selected with extreme care to avoid areas which have shown mosaic, anthracnose, and other diseases in excess.

As pointed out earlier, the red raspberry produces new plants from the roots of the parent plant. One-year plants are dug and bundled in spring for shipment by the nurserymen, as shown in Figure 288. Black raspberries and purple raspberries, are propagated from tips of canes which have bent over and taken root. If a large number of plants are desired for propagation, the canes can be covered with two inches of the soil in August, and they will soon root and be ready for transplanting the following spring, as illustrated in Figure 288.

Blackberries can be propagated from shoots from the roots as in the case of the red raspberry, using one-year-old plants. They are also propagated by root cuttings. In the fall, moderate to large roots of the blackberry are dug by nurserymen and cut into pieces two to four inches long. They are stored overwinter in moist but not wet sand or sawdust in a cool place not subject to freezing. In the spring these roots are laid four to eight inches apart in furrows three to four inches deep and covered with friable soil. Under good



(Bottom right) Ohio Agr. Exp. Sta., (Others) G. M. Darrow, U.S.D.A.

Figure 288. (Top left) Bundle of 27 Ronere (St. Regis) red raspberry plants as shipped from nursery. These should be heeled in, as shown at top right if they are not to be planted immediately. (Bottom left) All three are good nursery plants. Note difference between Ronere red raspberry, left, Columbian purple raspberry, center, and Cumberland black raspberry, right. (Bottom right) Raspberry plants should be fertilized with ammonium sulfate or a complete fertilizer about one month after planting, using two medium-sized handfuls per plant and distributed as shown.

cultivation and care the first season, these plants should be ready for sale and transplanting the following spring. Root cuttings can be made in the spring, but the percentage take is often considerably less. The plants also develop more slowly.

The dewberry can be propagated from tip or root cuttings, the tip cuttings being somewhat more popular.

When ordering from the nursery, specify No. 1 grade state-inspected stock with vigorous root systems. If the plants cannot be set to the field immediately on arrival, they should be heeled-in, as shown in Figure 288.

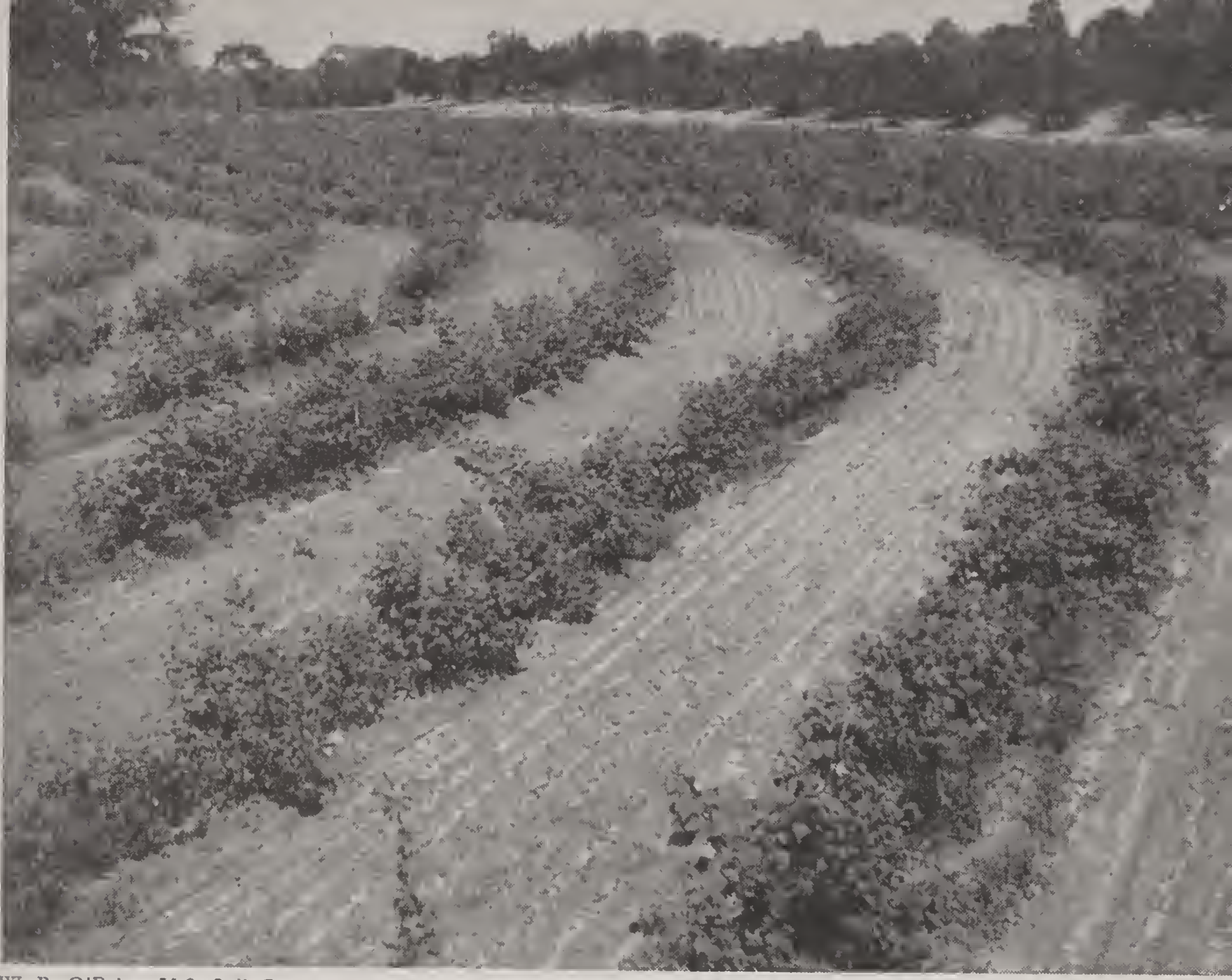
Bramble varieties vary with the region, depending upon hardiness of canes, productiveness, and ways in which the fruit will be utilized. Darrow and Waldo make the following varietal suggestions for the raspberry: Varieties ripening over a long season in western New York may consist of June for early and Cuthbert or Latham for a late red variety; for black varieties, the Farmer and Cumberland; and for purple varieties, the Columbian, Potomac, and Sodus. In the Middlewest, the red varieties should include Latham as the main sort, with Chief or King as early varieties and Taylor for trial to follow Latham; for black varieties, Logan is a good early variety, but Cumberland comprises the largest acreage with some Farmer and Kansas varieties; and for a purple raspberry, the Sodus, although few purples are being grown. In Washington and Oregon, the Cuthbert leads with Tahoma, a promising early, and Taylor and Washington promising late varieties. Farmer is by far the leading blackcap variety in the Northwest. In central California, the Ranere, and in southern California, the Surprise red raspberries are among the best. The Ranere is also grown in New Jersey, the Marlboro is popular in Colorado, and the Latham in Minnesota, inasmuch as the latter variety was developed by the Minnesota Agricultural Experiment Station. In some localities, other red varieties may be desirable, especially the new ones, such as Taylor, Marcy, and Newburgh, although the latter variety has shown too much susceptibility to winter injury in Michigan and Wisconsin. Where autumn-fruiting varieties are desired, the Ranere and Indian Summer are possibilities in the Northeast, whereas LaFrance, as well as Ranere, are receiving attention in California.

Care should be taken in selecting blackberries in order to obtain varieties that are sufficiently hardy in the northern states. Eldorado answers this requirement best. Varieties for semiarid regions of the Southwest include Crandall, Early Wonder, Dallas, MacDonald, and Haupt. Varieties frequently grown on the Pacific Coast are the Lawton, Eldorado (Stuart), Crandall, Himalaya, Evergreen, and Brainerd.

The Lucretia in northern and central regions, and the Young and Thornless Young in the South and West are the leading varieties of dewberry. The less-known partly self-fertile Premo, Chestnut, Manatee, and Rogers dewberries should be alternated, two rows each, with the self-fertile Lucretia, Young, or Mayes for cross-pollination.

Considerable work is being done on the improvement of brambles, particularly the raspberry, and thus the grower should keep in close touch with his local state experiment station.

Soil preparation. Soil preparation as described for the strawberry is equally desirable for the brambles. The soil should be in clean cultivation at least the previous year to reduce the weed problem as much as possible and get the soil into good tilth. High organic matter content is of paramount



W. R. O'Brien, U.S. Soil Conservation Service, Benton Harbor, Mich.

Figure 289. A contour-planted red raspberry plantation in Michigan. Note fine tilth of soil and special furrow cultivation to increase water retention and absorption. Adequate soil moisture is a most important factor in successful raspberry growing.

importance in successful bramble culture. This can be attained by turning under green manure crops the previous year or by the addition of eight to ten tons per acre of manure before planting.

Planting plans. The grower should consider the type of tools available for cultivation in laying out the raspberry plantation. Plants set somewhat further apart than necessary to accommodate available cultivating equipment will be less expensive to handle than plants set close and requiring considerable hand labor. If the land is sloping, contour planting is suggested (Figure 289). The main planting systems are the *hill, hedgerow,* and *linear.* With the *hill* system, it is possible to cultivate both ways across the field. Dewberries are frequently grown in hills, as are Latham and Marlboro red raspberries. The total yield is reduced as compared with the hedgerow system, but the fruits are large and usually of higher quality and are more easily harvested. A source of low-price stakes should be available. The hill system is suggested only on level or gently sloping land where erosion will not be a factor. The *hedgerow* system consists of a continuous row of canes covering a strip of ground about one to two feet wide at the base. It is adapted to the blackberry and to the red raspberry varieties such as Ranere, which tend to throw many suckers from the roots, making it difficult to maintain the plants in hills. Varieties particularly adapted to this training system have short relatively stout canes, such as Marlboro, King, Latham, and Herbert. Cuthbert and Ranere have slender stems which are often cut back lightly in spring so that they can better support their crop. Also, varieties with weak or relatively tall canes are frequently supported by different types of trellises.

The *linear* training system is more or less a modification of both the hill and hedgerow systems, in which no suckers are allowed to develop and the width of the row is restricted to the parent plants. The field, however, is cultivated one way only. Black and purple raspberries and some red raspberries are grown by this method. It is about the only system used in Washington where canes of the Cuthbert are grown quite tall and trellises are used.

Red raspberries are planted three feet apart in rows seven to eight feet apart for the hedgerow system or five to six feet apart each way where the hill system is used. This width is adapted to the use of small garden tractors which are in common use in average-size plantations. The possibility of skips in the hill system can be avoided to some extent by setting two plants 18 inches apart and two more 18 inches apart at a distance of four or five feet in the row. The two plants 18 inches apart are trained to the same post set halfway between. These planting distances are suggested for average vigor and soil fertility. The distances may be more or less, depending upon these conditions.

The black raspberry has a spreading and drooping growth habit and thus requires somewhat more space than the red raspberries. They are set as an average about four feet apart in rows eight to ten feet apart. Purple raspberries are more vigorous than the black varieties and thus require about ten feet between rows. The blackberry is also quite vigorous and requires about the same planting distance.

Planting brambles. Plow out furrows in one direction deep enough to accommodate the root systems, and cross-mark the field in the other direction at points where the plants will be set. The plants can be carried to the field in tubs of water and distributed from pails containing muddy water. Plants should be dropped only a short distance ahead of the planters to protect the roots from drying. Dull cloudy days with little or no wind are the best for planting. The plants are placed against the straight side of the furrow about two inches deeper than they grew in the nursery. Soil is pulled around the roots and well firmed with the foot. The growing tip of the black and purple raspberry plants, which is curled upward, should not be covered with soil. Another system for planting is to use a spade which is pushed into the ground and shoved forward. The plant is inserted while shaking out the roots, the spade withdrawn, and the soil well firmed with the foot. Only the vigorous well-rooted plants should be used, as illustrated in Figure 288. With one man planting and a boy dropping plants, a large number can be set per day.

Soil management. Work the soil toward the plants while cultivating. Except for contour plantings, cultivate both ways frequently during the first season to reduce weed competition and increase soil aeration and rainfall penetration. Any practice which increases or maintains moisture supply among brambles is an important factor in success with these crops. The brambles are all shallow-rooted and are the first to show the effects of drought.

Cultivation should cease around the first of September and the hoe used thereafter to eliminate weeds, except in the colder northern states where even hoe weeding may induce succulent cane growth susceptible to winter injury. Cultivated vegetables may be grown between the bramble rows the first year, but they should be removed by around the first of September for the same reason. The better the weeds are controlled the previous year, the less the difficulty with them during the fruiting season.

Shallow cultivation should be practiced after the first year. This is especially true next to the rows with the red raspberry and blackberry which sucker more freely if the roots are frequently cut and broken. Teeth of a spike-tooth harrow can be set at more of an angle next to the rows in order to accomplish this. Hand removal of the suckers is highly effective in reducing sucker growth, but expensive. A spring-tooth harrow with some of the teeth removed can be used for making shallow furrows for collecting moisture on a contour-planted field, as shown in Figure 289. One cultivation during the harvesting period may be desirable, provided the soil is not too dry and dusty. If the canes are drooping into the rows, cultivation will necessarily have to wait until after harvest.

In most sections, a cover crop is sown, or, preferably drilled in mid- to late August. If the crop lives overwinter, such as rye, it should be kept well away from the rows and disked down before it joints the next spring. A method often used for killing rye is to plow toward the row about April 1 and pull the soil away from the row two weeks later with a grape hoe. Oats seeded at the rate of three bushels per acre will make a good cover and die overwinter. Other crops often used are cowpeas, vetch, millet, and the different clovers.

Mulching with straw or leaves to a depth of six to eight inches each year is frequently practiced to maintain moisture supply. Where mulch is used, either manure or a nitrogen fertilizer should be applied to avoid a nitrogen deficiency. Manure with a high percentage of straw and free of weed seed makes an excellent mulch when available. Mulch has been known to increase yields by three to five times, but it is a real fire hazard in large commercial fields in dry seasons.

Irrigation. Provision for irrigation is good insurance against drought in almost all regions. Irrigation is a necessary practice in the arid and semiarid sections of the Southwest and Pacific Coast. In the humid sections of the Northeast, good crops may be grown without irrigation, but even in this area there are frequently periods when irrigation would increase the crop considerably. The overhead, furrow, or sprinkler systems as described for strawberries may be used. Brambles require a good irrigation about as often as shallow-rooted vegetables, which is once every week or two during dry periods.

Fertilization. The importance of additions of large quantities of organic matter to bramble plantations cannot be overemphasized. The moisture-holding capacity, tilth, and aeration of the soil is greatly improved by organic matter. In addition to a heavy application of barnyard manure at the time the land is plowed and prepared, about eight to ten tons of manure applied per acre each year thereafter is one of the most effective means of maintaining vigorous growth and high fruit production.

Specific fertilizer recommendations for each bramble are difficult to make because soil conditions vary tremendously from one region to another and from one location to the next. It is highly recommended, therefore, that the grower maintain small test plots to determine the value of nitrogen, phosphorus, and potassium together and separately. It is generally known that black raspberries usually show the most response to fertility—the more fertile the soil, the stronger the growth and the larger the crop. Fertilizer requirements of purple raspberries are similar to those for the black varieties. While red raspberries respond to a fertile soil, their fertilizer requirements are not so well understood. Michigan studies have indicated that the larger the cane diameter, the more productive the canes; branched canes produced more than unbranched canes. Darrow and Waldo report that the best yields of red raspberries in the United States are obtained where annual application of two to 15 tons of stable manure per acre are made in addition to 400 to 500 pounds of a complete fertilizer. Judkins shows a 20 to 40 per cent increase in yield of Latham red raspberries receiving 500 pounds per acre of ammonium sulfate in the spring of each year in Ohio. If manure is not available, 200 pounds of nitrate of soda per acre applied to black raspberry fields at blossom time is suggested for trial. Five hundred pounds of cotton seed meal is often used in place of 10 to 15 tons of stable manure.

Blackberries have shown a greater response to nitrogen in the southern limits of the industry. Where stable manure, 20 tons per acre, is not available, Darrow suggests trying 600–1000 pounds of a 4–8–4 fertilizer. Less manure and fertilizer will be needed where green manure crops are turned under each year between the rows.

For dewberries in North Carolina, two applications of fertilizer per season are often made after the first year, one immediately after the canes have been tied to stakes or the trellis in spring and the other shortly after the crop has been harvested and the old canes removed. First application consists of a 2–10–8 complete fertilizer applied at the rate of 500 to 700 pounds per acre. Second application usually consists of 500 to 800 pounds of cotton seed meal plus 100 pounds of nitrate of soda, or, if available, 10 to 20 tons of manure per acre.

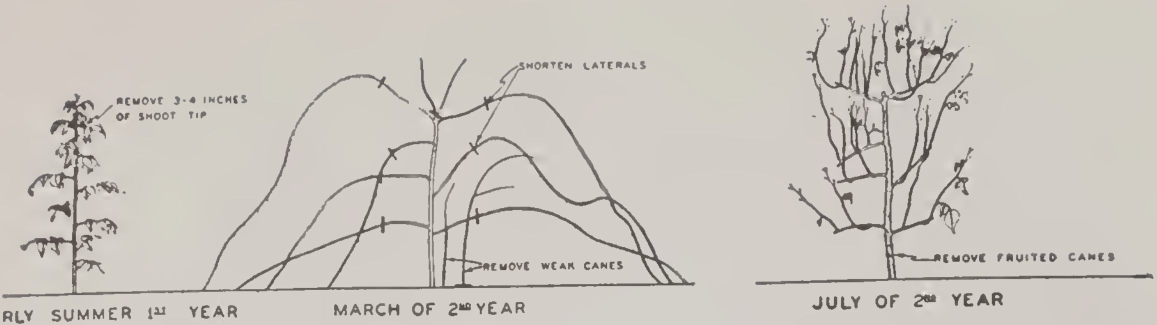


Figure 290. *Black* and *Purple raspberries* produce shoats from the roots early in the growing seasan. When shaots attain proper height, summer pinching induces vigoraus laterals which are shortened the fallowing early spring. Bearing canes are removed immediately after harvest. Nate tips of long laterals have taken root in center plant. New plants can be obtained by this means. Tips af laterals are cavered in August with two inches af soil ta induce roating, and they are remaved from the mather plant the next spring, leaving abaut six inches of mother cane for canvenience in transplanting.

Overfertilization should be avoided in northern states where winter freezing is a factor. A late summer cover crop, fertilized when necessary to induce heavy growth, will serve to harden the canes and reduce winter injury to a minimum.

Training and pruning brambles. Fruit of brambles is borne on canes which arise from the roots one year, fruit the next, and die shortly after. It is necessary to remove these old canes in midsummer every year, along with the weak late-developing new canes. Otherwise, the rows will become dense and crowded with old and weak wood, resulting in low production of poor-quality fruit. Some dormant and summer trimming of the new canes also is needed, depending upon the bramble in question.

Black and purple raspberries and upright-growing blackberries require *summer pinching* of the tips of new shoots (Figure 290). The top three or four inches of the new shoots are removed with gloved fingers or shears when they have attained a height of 18 to 24 inches for black raspberries, and 30 to 36 inches for purple raspberries and blackberries, depending upon vigor. This induces laterals to develop and results in a low stout plant. The tips of new shoots should be removed at weekly intervals or as they appear before and during harvest.

Red raspberries are *not* summer pinched (Figure 291). Soon after the canes of all brambles have fruited, they should be removed close to the ground and burned.

The *dormant pruning* should be done in spring after danger of freezing and before the buds begin to swell. Red raspberries in most plantations are given only light cutting back of tips to prevent canes from later becoming top-heavy with fruit and bending to the ground. If trellises are used, little or no heading back of canes may be required. In areas such as the Northwest where conditions are favorable for tall growth of canes, trellises are generally needed and less heading back is practiced. It is readily possible to cut back too heavily and greatly reduce the crop. Where no trellis is used, the least amount of heading required to keep the canes from bending into the rows and to the ground is the most desirable. Small spindly canes should

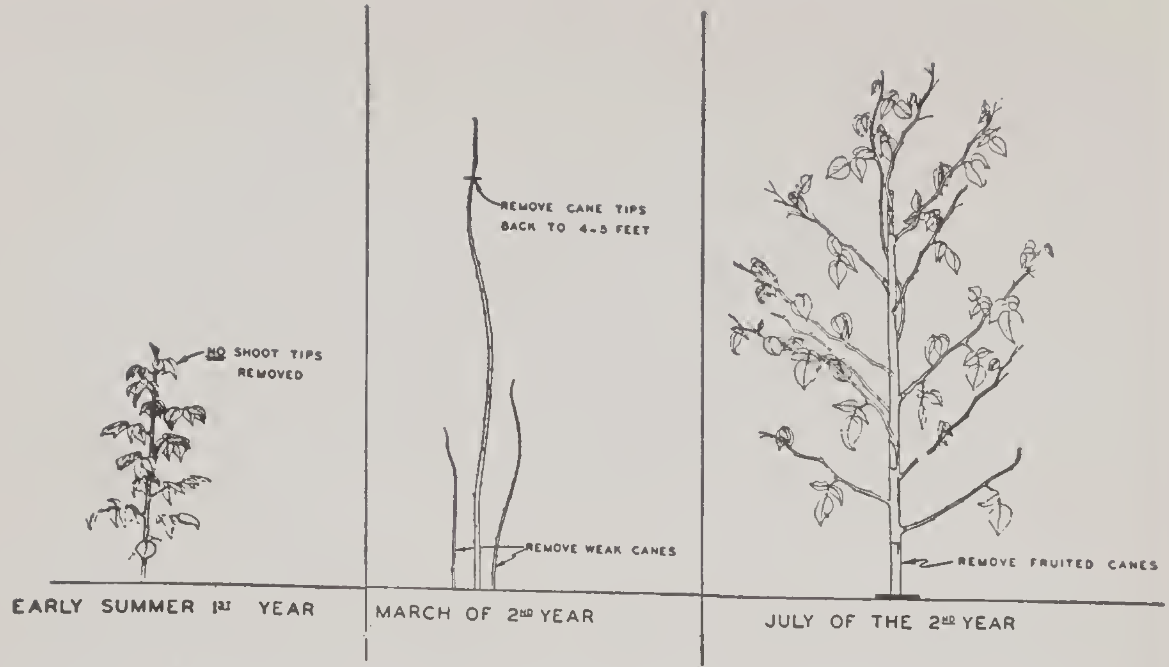


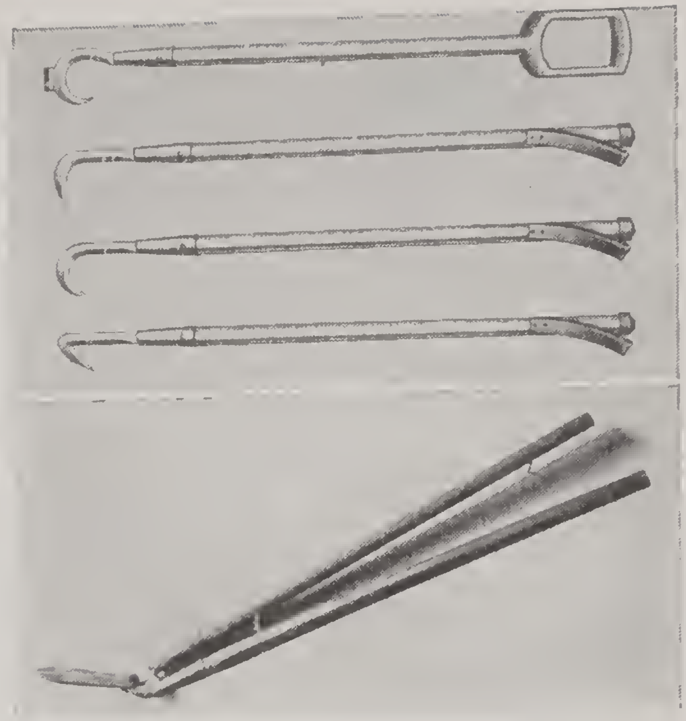
Figure 291. Red raspberry produces shoots from the roots; they require no summer pinching. Few, if any, laterals are formed. In spring of the following year, weak canes are removed and tips of remaining canes are cut back according to growth and variety. Immediately after harvest, fruiting canes are removed and burned.

be removed from the hedgerow, leaving the larger canes which are one-half-inch or more in diameter. From five to eight canes should be left for hills or about ten canes for every four feet of the hedgerow. Canes in the hedgerow should be confined to a strip about 12 inches wide at the base. This is known as the narrow-hedgerow and is preferred to the wide-hedgerow which is 24 to 36 inches in width at the base. Two No. 12 gauge wires on either side of five and one-half foot posts spaced 15 to 30 feet apart are sufficient for supporting tall- or weak-cane varieties grown by this system. These canes may be braced further by tying them to the wires on either side and allowing the new canes to grow up between.

In case of black and purple raspberries and blackberries which have been summer pinched, it is necessary to prune back the laterals rather heavily in March. For black raspberries, the size and the quality of the fruit is improved by leaving the stronger laterals with from eight to twelve buds on branches about eight inches long after pruning. In areas where drought periods are likely to occur, such as southern Michigan, only four to six buds are frequently left per cane, resulting in larger better-quality fruit. Weaker laterals may be cut shorter and very vigorous laterals left somewhat longer. The fruiting shoots will arise in spring from axillary buds along these laterals, with a few arising on the main cane itself.

Laterals of purple raspberries are pruned back to 10 to 18 inches, depending upon their vigor. Longer laterals are left for purple varieties because there is a tendency for the buds at the base of laterals to be vegetative. Small spindly laterals should be removed entirely. Yield may be reduced if fewer than five laterals are left per cane. Do not remove canes over one-half inch in diameter at the ground level, as thick canes are, as stated previously, the most productive. However, it is advisable to remove any surplus raspberry canes smaller than one-half-inch in diameter. In the East, black and purple raspberries are not usually supported, but in the Northwest a two-wire trellis three feet high is often used. The wires are attached to 18-inch wide wooden cross arms on low posts spaced 25 to 35 feet apart in the rows.

Laterals of blackberries which have been summer pinched should be left about 18 inches long. With blackberries, it is perhaps better to wait until the blossoms appear before the laterals are cut back. Some varieties tend to bear fruit far out on the lateral and such a practice prevents cutting away too much of the crop. This is particularly true of the Eldorado variety which is recommended in many regions. The strongest canes are thinned in the row to about ten inches apart. The plants are sometimes tied to a one-wire trellis two and one-half feet above the ground on low posts 15 to 30 feet apart. This holds the bushes in line and facilitates cultivating and harvesting. A two-wire vertical trellis may be employed for trailing blackberries as shown in Figure 293. Other trellis styles are described by Darrow.



G. M. Darrow, U.S.D.A.

Figure 292. (Top) Raspberry-cane cutters for removing old canes and superfluous new ones. Handles and sickle are about 34 inches long. (Bottom) Long-handled shears with cutting blades bent upward to enable pruner to cut dewberry canes close to the ground with but little stooping and scratching of hands.

The dewberry is usually planted in hills and trained to seven and one-half-foot stakes which are sunk in the ground about two feet. After the crop is harvested, old canes are removed and the patch is cultivated in one direction until the canes seriously interfere. Cultivation is then discontinued and the canes allowed to grow at random over the ground. The following March, seven or eight of the strongest canes in the hill are tied spirally around the stake at each hill and cut to a height of about five feet.

A special system of planting and pruning dewberries is practiced in the Gulf States where no stakes are used. Plants are set 18 to 36 inches apart in the row and allowed to form a matted row. Before picking, the new shoots are cut back to reduce interference with the picking operation. After harvest, the canes, old and new, are cut close to the ground with a mowing machine and burned where they lay after they have dried. Cultivation in one direction is then practiced while the new canes are developing for the crop the following year.

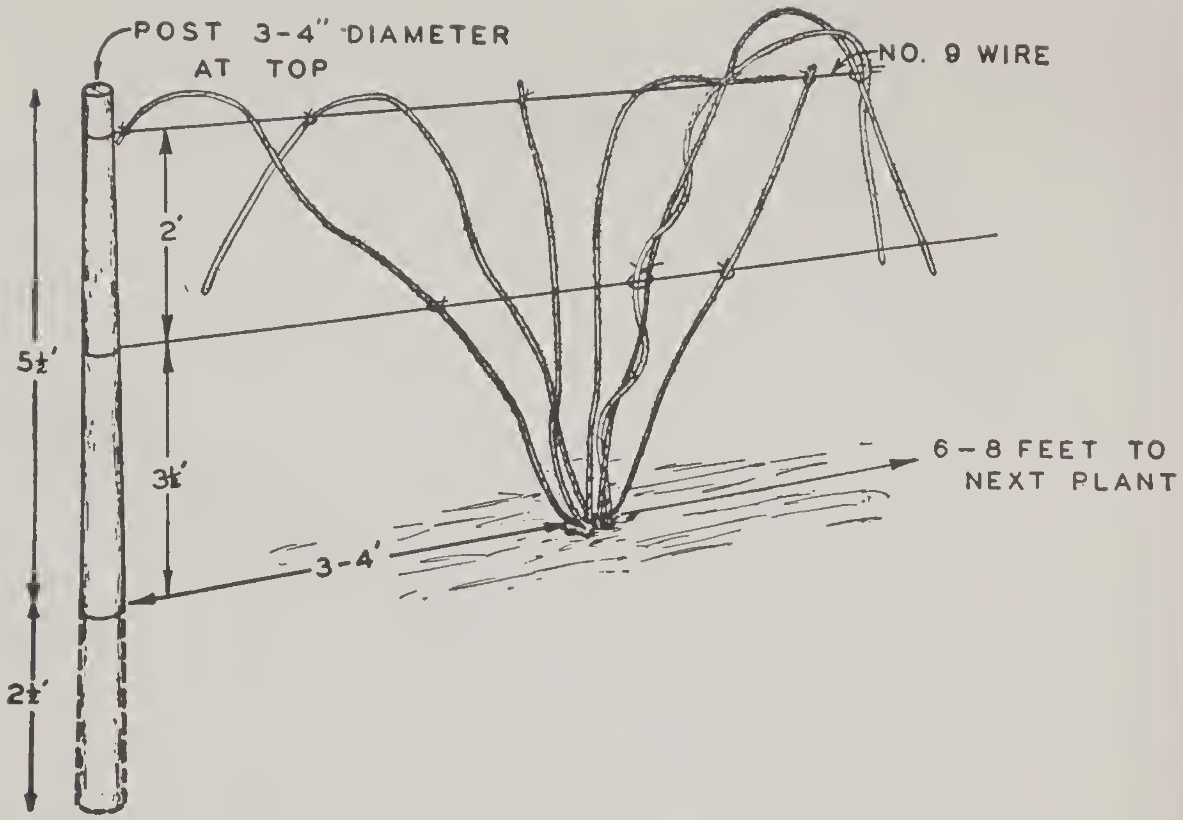
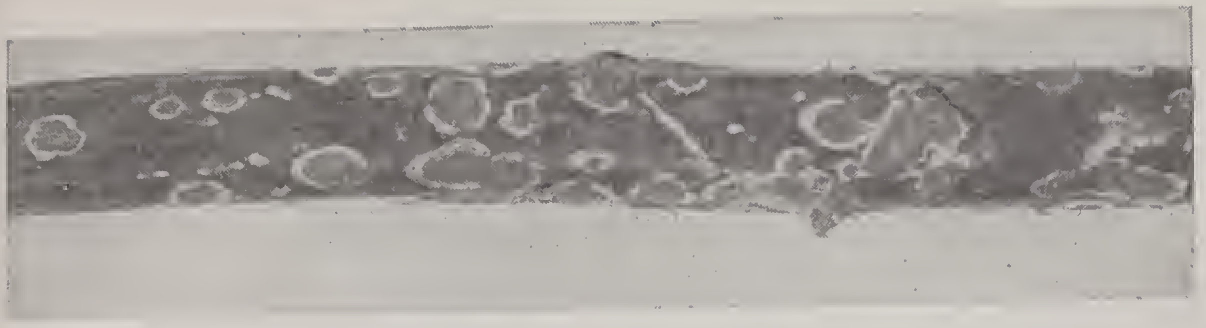


Figure 293. A two-wire trellis is convenient for training the trailing-type blackberry, Boysenberry, Youngberry, and dewberries. Trellis should be established before the beginning of the second year.

The Young and Boysen dewberries are vigorous trailing varieties which are usually trained to a two- or three-wire vertical trellis (Figure 293). During March pruning, the canes are cut about five or six feet long, or longer if vigorous, and tied to the wires fan fashion. New canes which arise at the ground surface in the spring are allowed to trail along the ground in the direction of the row. As soon as the old canes have fruited in summer, they are removed close to the ground and burned. Since these brambles are very thorny, it is wise to wear boots, heavy trousers, a coat such as a hunting outfit, and leather gloves during the pruning operation. Brambles may last indefinitely in some well-kept plantations, but in most cases they are renewed every 10 to 15 years by plowing up the roots and setting new plants, preferably on a new location.

Controlling insects and diseases. Diseases and insects of brambles, although relatively few, may in some cases become serious. The following diseases are among the more common. *Anthracnose* (Figure 294) may be destructive on purple and black varieties and less damaging on red varieties. On the canes it is characterized by oval spots with a purple edge and a sunken light gray center. *Crown gall,* a difficult disease to control, appears as "cauliflower" swellings on the roots, crown, or lower part of the cane. Blackberries and dewberries are most susceptible. Most serious diseases of raspberries are the viruses, such as *leaf curl* (deep green leaves curled downward and inward), mosaic (leaves green and yellowish-green mottled), and



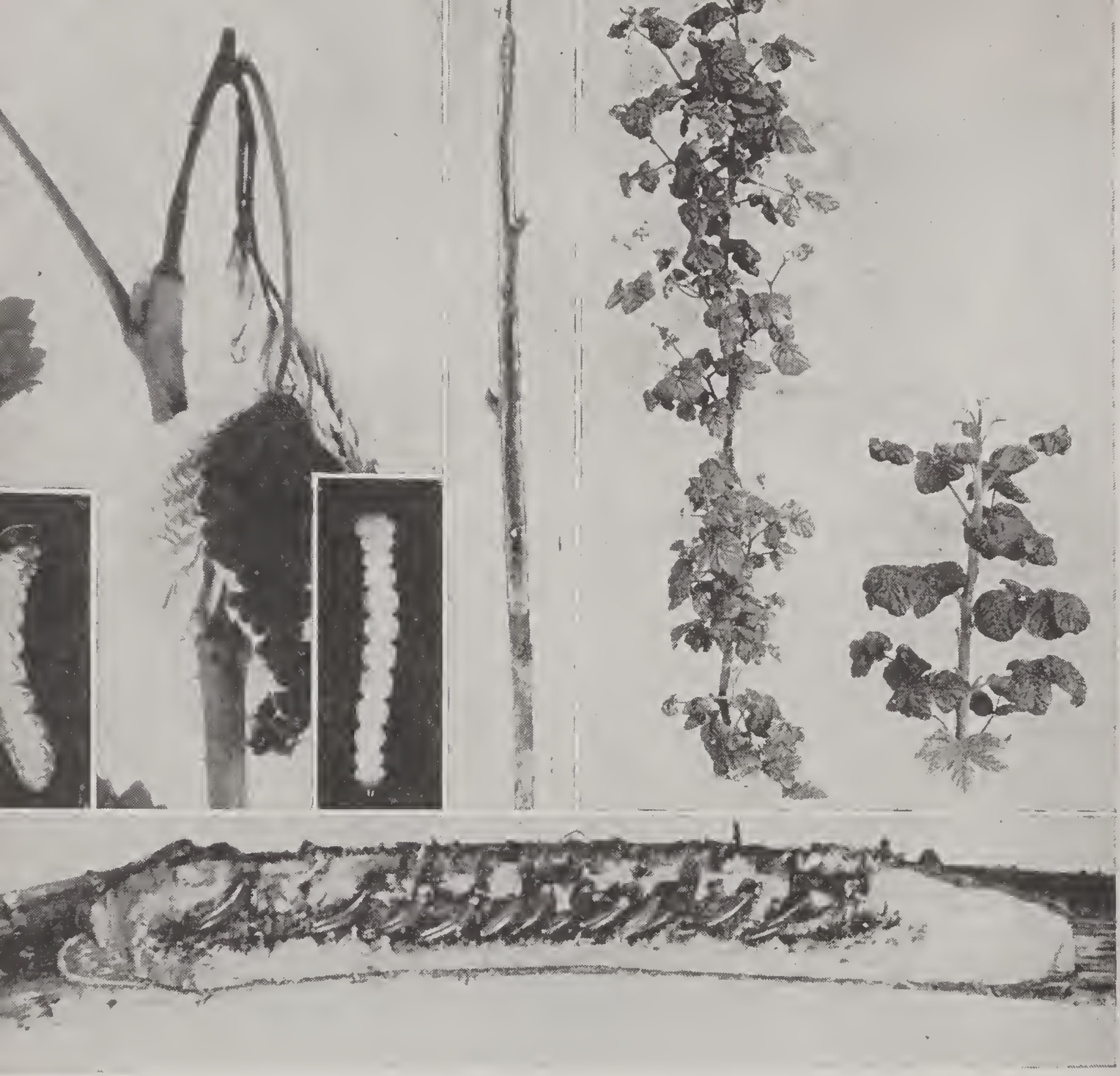
Ohio Agr. Exp. Sta.

Figure 294. Anthracnose is a common disease affecting brambles, especially black raspberries. Disease may markedly reduce yield or kill the canes. It is controlled by a delayed dormant lime-sulfur spray.

streak (reddish or purple stripes on canes in midsummer, in addition to leaf mottling and curling). Black and purple raspberries are more likely to succumb to virus diseases. Red raspberries may be damaged only slightly, but it is possible for the virus to be spread from red raspberry plants to purple or black raspberries by plant lice. *Orange rust* is destructive to blackberries and dewberries and occasionally to black raspberries. *Double blossom* may seriously affect dewberries and blackberries in southern regions.

Best control of raspberry diseases is attained by observing the following precautions: (1) Plant the most disease-free plants obtainable. Seek only government-inspected plants. (2) Keep plants growing vigorously by good cultural practices. (3) Immediately after planting, remove and burn handles or portions of the old cane on black and purple raspberry-tip plants. (4) Remove old diseased raspberry plantings to prevent spread of disease to new plantings. (5) Pull into the middle of the row and burn with a blow torch all plants showing such diseases as the viruses and rust. (6) Remove old fruiting canes immediately after harvest and burn in piles outside the patch. (7) Remove and burn all dead canes when pruning in spring. (8) Spray every spring when buds show one-half inch of green, with dry lime-sulfur, one pound in two and one-half gallons of water for anthracnose control.

The following insects are among the most troublesome (see also Figure 295). *Red spider* injury results in a grayish lusterless cast of the leaves. Spiders are tiny, more greenish than red, and move slowly over the leaf surface. In case of severe injury, leaves may become brown and die. Hot dry weather favors the pest. A spray containing one pint of white or summer spray oil in 12 gallons of water and applied with high pressure as soon as mites are seen is often helpful. More than one application may be necessary. The *tree cricket* punctures the canes and lays eggs, stunting the canes; the *crown borer* may be destructive in some western bramble sections; the *cane borer* girdles young canes and bores downward into roots. The *raspberry saw fly* larvae feed on leaves in northeastern sections west of the Mississippi River. *Raspberry beetle* may cause numerous wormy red raspberries. See local spray recommendations of your state experiment station.



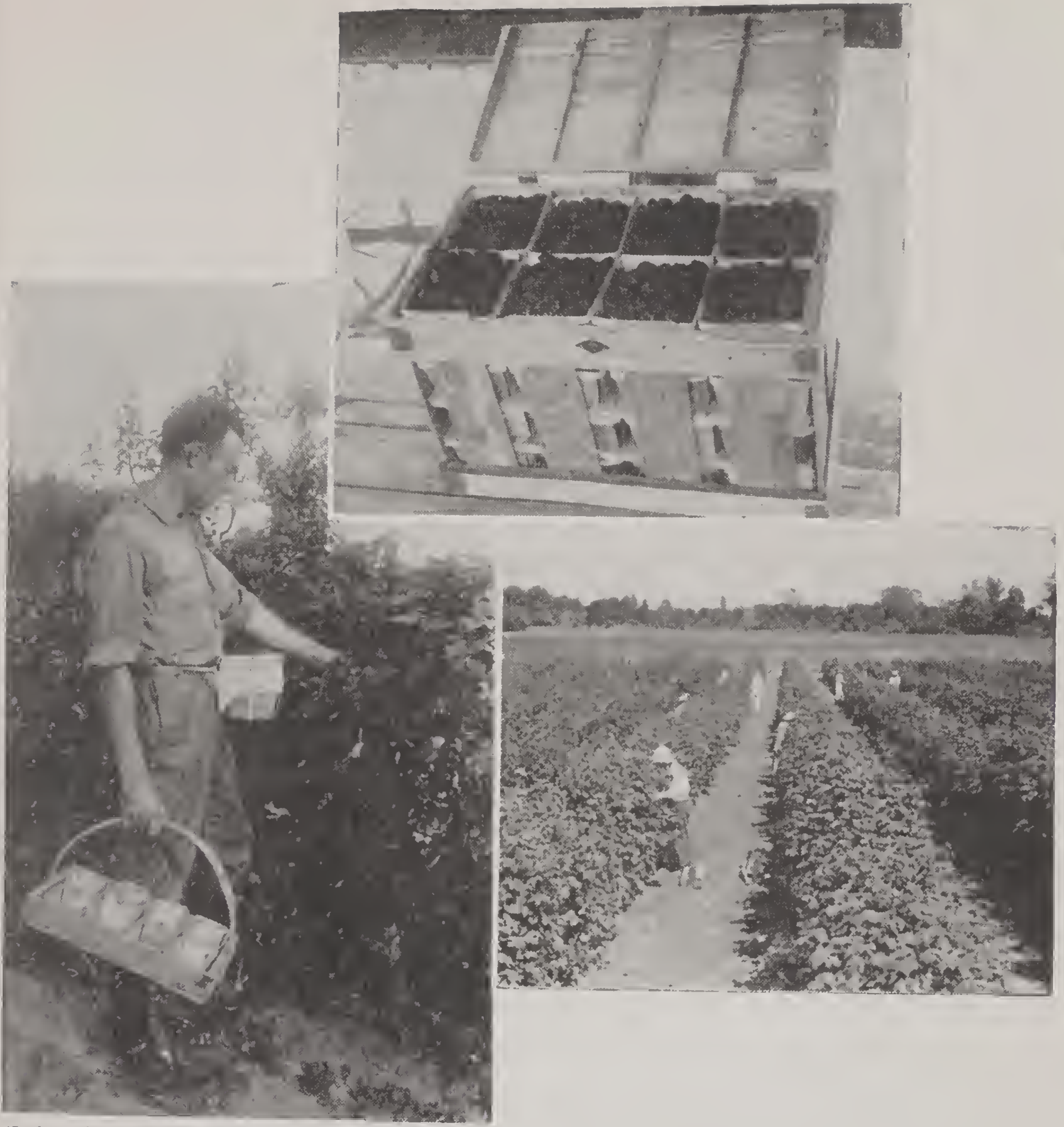
F. G. Mundinger, New York Agr. Exp. Sta.

Figure 295. The top left photo and the left inset show larva and damage by raspberry cane-borer (*Oberea bimaculata*). The right-hand inset in the left photo shows the larva of Buprestid cane borer (*Agrilus spp.*). The top middle photo shows a cane injury due to larva of borer shown in left inset of top left photo. The top right photo shows leaf curl symptoms (a virus) on Cuthbert fruiting cane at left, and new shoot tip at right. The bottom photo shows tree cricket eggs which weaken or kill the raspberry canes.

HARVESTING AND MARKETING BRAMBLES

Brambles, particularly red raspberries, are among the most perishable fruits. The harvesting season should be well organized with sufficient packages on hand, adequate pickers previously contacted, and the marketing channels clearly defined. Brambles reach a peak of maturity quickly and deteriorate as rapidly.

Raspberries should be picked when dry and as soon as they separate easily from the clusters. At the peak of the season, they are harvested two or three times a week, sometimes more often if the weather is hot and dry. The thumb and two fingers are used with great care to avoid bruising. Only a



(Left and top) G. M. Darrow, U.S.D.A. (Right) Oregon Agr. Exp. Sta.

Figure 296. Harvesting brambles. (Left) The wire and canvas picking carrier on the workman's waist holds a quart berry basket by a canvas snap-strap. Carrier and basket are not likely to spill berries when picker bends over. Filled baskets are placed in eight-pint or six-quart carrier at picker's right. (Top) Lucretia dewberries from North Carolina in a 32-quart crate. Container is used also for blackberries and most small fruits except the red raspberry which is more perishable and packed in pint crates. (Right) A typical raspberry harvesting scene in Oregon. Note large well-developed hedgerows as a result of irrigation and good management.

few berries should be held in the hand at one time to avoid crushing. The berries are picked and placed, not dropped, directly in the boxes in which they will be marketed. Quart boxes are used for black and purple raspberries and for blackberries and dewberries. Pint boxes are used for the more tender red raspberries to protect them against bruising and mashing. A picking box and carrier are shown in Figure 296. The picker should fill one box at a time in order to avoid excessive jarring and settling of the berries. Jarring not only injures the berries, but reduces the volume yield and cash returns. The berries should be handled as little as possible and kept in the shade of the bushes or shed after removing from the plants.

Best period for picking berries is early in the morning until about ten o'clock on sunny days; the hot midday period should be avoided as much as possible. Cool cloudy days are ideal for picking. Ripening and rotting, on the other hand, are accelerated by wet humid weather. Pickers required per acre will vary from six to twelve, depending upon their efficiency, the yield, and other factors. Red raspberries are marketed in 16- to 24-pint crates; other brambles are assembled in 24- or 32-quart crates (Figure 296). Precooling and refrigeration is recommended for shipment, or, for a short holding period. Red raspberries when properly handled can be successfully shipped fresh by refrigeration from the West Coast to the East. With the development of air transportation, increasing quantities may be shipped by this means. Freezing preservation appears to be one of the most convenient and best ways of shipping and handling the brambles, particularly red raspberries.

Blackberries and dewberries are picked when the berries are black and can be removed from the cluster while still firm. Eldorado blackberries can be picked soon after they turn black but most varieties are not ripe at this time. Berries which are black but difficult to remove from the cluster may be sour. Avoid exposing picked berries to sun as bitterness may develop. Pneumatic tires and vehicles with springs should be used in transportation to reduce jarring and settling to a minimum.

The same picking procedure and supervision as recommended for strawberries can be utilized with brambles. The card is punched as containers are brought to the shelter. The punches should be changed frequently to avoid fraud. Some growers believe the best system from the standpoint of both pickers and manager is to pay the picker in change every time he brings a carrier of baskets to the shelter. This precludes any confusion and misunderstanding later.

Uses. A large quantity of brambles are eaten fresh. In recent years, however, raspberries, particularly the red variety, are being frozen in large quantities for one of the most popular frozen fruit trades (Chapter XVIII). Some blackberries and dewberries are frozen, but the product is not quite comparable with red raspberries. Brambles in general and blackberries and dewberries in particular are made into jams, jellies, and preserves and canned in tins or glass jars.

Yields. Average yield for the United States is less than 1000 quarts per acre, but this is a poor standard. In regions where brambles are adapted, the purple raspberries yield the best, followed by the black and red varieties in order. Under average to good care, purple varieties should yield about 2500 quarts per acre; black varieties, 2000 quarts; and the red raspberries, from 1600 to 1800 quarts per acre. Yields in excess of these figures are not uncommon. In fact, in the northwest the Cuthbert and Marlboro may yield as much as 4000 to 8000 quarts per acre.

Under good management, blackberries and dewberries may yield from 2200 to 5000 quarts per acre or more, with Himalaya and Evergreen black-

TABLE 42

Man-Labor Requirements Per Acre for Brambles in Oregon, 1942

(Adapted from Blosser, Franklin, and Mumford)

Operation	Man Hours per Average Acre			
	Red Raspberries	Black Raspberries	Boysenberries and Youngberries	Loganberries
Removing old canes	38.8	22.1	29.5	20.0
Topping	11.9	14.6		
Brush disposal	3.0	5.7		
Repairing trellis	3.3	.6	3.4	2.2
Training	8.0			
Pruning laterals		16.5		
Staking and laying back			15.9	24.0
Gathering stakes			2.8	2.4
Brush disposal (fall)			8.5	5.8
Pruning, brush disposal, and training			47.4	36.4
Total for maintenance	65.0	59.5	107.5	90.8
Fertilizing (commercial)	2.0	1.4	.5	1.5
Manuring	1.8	1.8	4.0	6.0
Seeding cover crop	1.0	.8	1.1	1.1
Hauling and spreading straw			.6	
Total for fertilizing	4.8	4.0	6.2	8.6
Plowing	1.5	2.2	3.1	5.8
Grape hoeing	4.0	2.3	3.3	1.9
Disking	5.4	6.0	7.4	4.1
Other machine cultivating	1.7	2.2	1.2	5.5
Harrowing		5.1	3.3	4.2
Hand hoeing	18.2	23.8	10.8	14.6
Cross cultivating		4.5		
Total for cultivating	30.8	46.1	29.1	36.1
Baiting for weevil	2.3	.3	.5	
Spraying		.1	5.7	6.8
Irrigating			.3	
Picking	382.6	232.8	262.2	279.9
Supervising, weighing, and checking	42.9	27.8	29.1	31.1
Hauling pickers	6.0	1.3	1.1	2.1
Hauling berries	9.2	10.4	8.6	8.0
Cleaning up camp	.4			
Total for harvesting	441.1	272.3	301.0	321.1
TOTAL FOR ALL OPERATIONS	544.0	382.3	450.3	463.4

berries under favorable conditions in the Northwest yielding 10,000 to 20,000 pounds a year. These brambles, however, ripen at a warmer season than raspberries and thus an unfavorable hot dry season may reduce yield considerably.

Man-labor required. Harvesting operations require the most labor, followed in order by pruning, cultivating, and fertilizing. The following data from Oregon are typical.

Winter protection of canes. In regions where drying winds occur frequently and there are sharp temperature changes, it may be necessary to cover the canes with two to three inches of soil during the winter period. Advice of local growers should be considered. The dewberry in the region of southern Michigan is frequently covered with soil for winter protection. Plants should be covered before the ground freezes and after most of the leaves have shed. A furrow three inches deep is plowed out close to one side of the row. Using long-handled pitchforks, the canes are pushed into the furrow. Direction of the plow is reversed, drawing the soil over the ends of the canes to pin them in place. Several men may be required to assist in the operation. One or more additional furrows may be plowed onto the canes if more complete coverage is desired. Canes should be uncovered before growth starts in spring. A special homemade implement with a wooden shelf to guide the canes downward and one plow on either side to cover them is described by Darrow. The covering job can be done rapidly with this tool in large plantations.

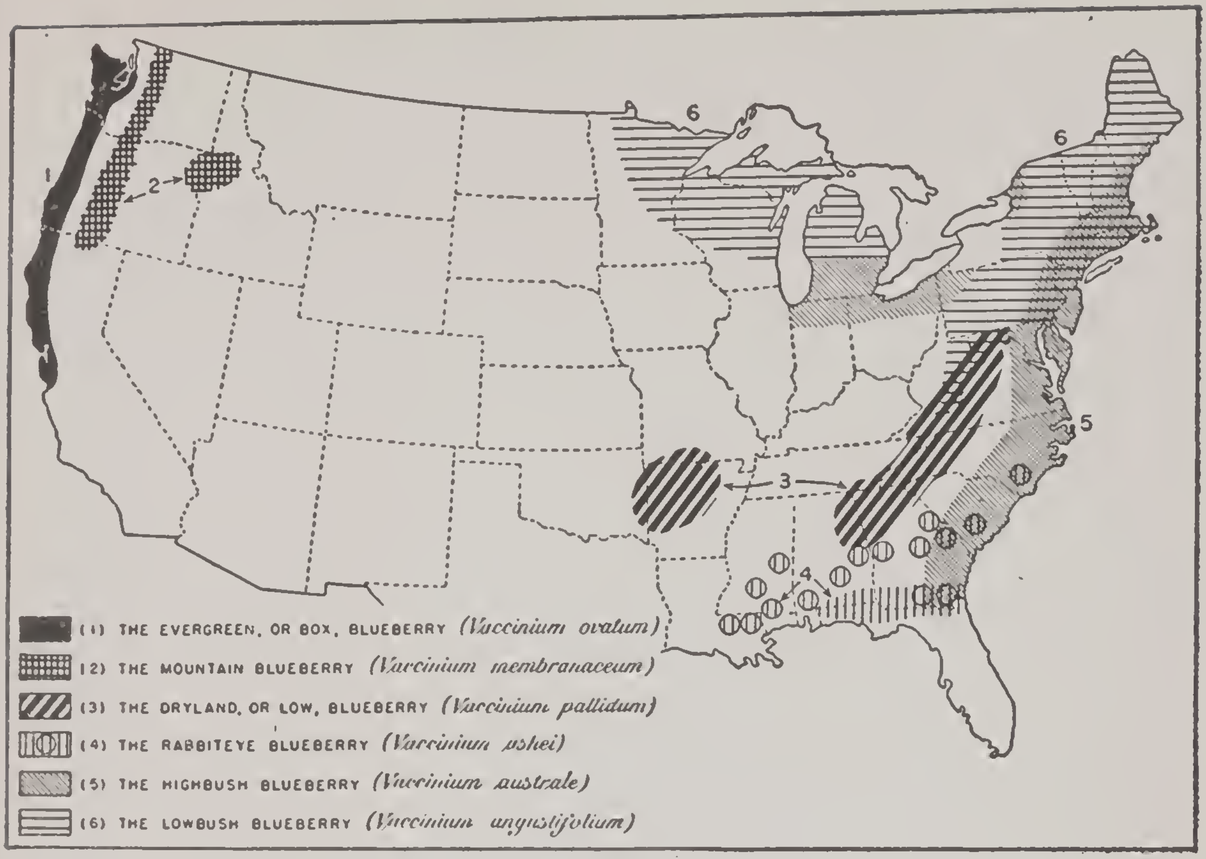
Judkins gives striking data in favor of mulching Latham raspberries in northern Ohio to reduce heaving, low vigor, and a general dying of the plantation.

BLUEBERRY CULTURE

The blueberry grew wild in America before the white settlers landed. Because there was an abundance of wild berries, no effort was made to develop improved varieties until 1906 when Dr. F. V. Coville of the U. S. Department of Agriculture initiated a cultural and varietal improvement program. Blueberries obtained either from the wild or from cultivated varieties are now one of the most popular small fruits on the market.

Different species of blueberries are found growing naturally from the low moist bog land in New Jersey to the high relatively dry uplands of Georgia and Maine. They are now being cultivated in many sections of the United States on acid soil ranging from the sandy to clay types. In 1943, New Jersey had about 2,000 acres under cultivation; North Carolina, 500; Michigan, 500; and other states, including Washington, Oregon, Massachusetts, and New York a total of around 100 acres. Value of the cultivated crop in 1943 in New Jersey was $1,000,000; in North Carolian, $225,000; and in Michigan, $300,000. The total value of the crop, however, is considerably more than $1,500,000, due to the fact that a much greater quantity is harvested from wild blueberries growing in widely separated areas (Figures from Darrow).

There are several commercially important wild species of blueberries distributed over the United States, six of which are shown in Figure 297. Selected varieties from only two of these, the highbush and rabbiteye blueberries, are being commercially propagated, although similar progress is being made


1
2
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6
(1) THE EVERGREEN, OR BOX, BLUEBERRY (Vaccinium ovatum)
(2) THE MOUNTAIN BLUEBERRY (Vaccinium membranaceum)
(3) THE DRYLAND, OR LOW, BLUEBERRY (Vaccinium pallidum)
(4) THE RABBITEYE BLUEBERRY (Vaccinium ashei)
(5) THE HIGHBUSH BLUEBERRY (Vaccinium australe)
(6) THE LOWBUSH BLUEBERRY (Vaccinium angustifolium)

G. M. Darrow, U.S.D.A.

Figure 297. Distribution of six important species of wild blueberries in the United States. These are extensively harvested and marketed fresh, frozen, or canned. Plantings of the selected and cultivated highbush varieties are spreading and increasing in number.

with other sorts. Blueberries have many small soft seeds, as differentiated from the so-called huckleberries which have ten large bony seeds.

Lowbush blueberries are found growing wild in the northeastern states and Canada and are the most important commercial species. They grow from 6 to 18 inches high in upland areas, spreading by underground shoots. Fruit is harvested before the highbush blueberry and the season may extend from July into September. The crop is harvested largely for canneries with hand scoops about 12 inches wide with 18 to 40 teeth, or with a five-tooth rake. Value of the marketable crop is over $5,000,000, but the entire crop is by no means harvested.

The lowbush blueberry takes over after the forest is cut. In Maine in early spring, many areas are burned over every second or third year to destroy weeds and prune the plants. Mowing is recommended over burning to conserve fertility; according to studies in Maine, it is effective in reducing troublesome weeds from 80 to 99 per cent. It is often necessary to control the blueberry fruit fly in these areas by extensive dusting.

Highbush blueberries grow wild from Florida to Maine and west to southern Michigan. Annual crop value from wild plants varies between $1,000,000 and $1,500,000; value of the cultivated crop in 1943 was over $1,500,000. The plant grows from 10 to 15 feet high, performing best in swamps and moist fields at high elevations; it is subject to drought. Rubel is a common selected variety used in commercial plantings. Most of the discussion on culture in this chapter is devoted to this species.

Dryland blueberries are of chief importance from northern Alabama and Georgia to Maryland and West Virginia. The plants are from one to three feet high, drought resistant, spread by underground shoots, and can thrive in relatively poor soils on ridges and hills. The light blueberries, of which there are no named varieties, have good flavor and ripen later than the lowbush and highbush sorts, but come on the market at good prices before the New Jersey blueberries. Annual value of the harvested crop is about $300,000 or more.

Evergreen blueberries are gathered extensively and shipped in September and October from Oregon, Washington, and upper California. In addition to the fruit crop which is valued at from $150,000 to $200,000 annually, large quantities of branches are shipped to the East as an "evergreen huckleberry" for decorative purposes. The plant reaches a height of 20 feet in open woods and can be used as an attractive ornamental shrub. Berries are shiny black with a strong flavor which makes them less desirable than other blueberries, but they are good in pies and for cooking.

Mountain blueberry, or "broad-leaf huckleberry," is found in the Northwest where the annual harvested wild crop totals around $200,000. This drought-resistant blueberry is three to five feet high. The berries, borne alone and in pairs, are pear-shaped, black or maroon, highly flavored, juicy, and tart. No cultivated plantings are known.

Rabbiteye blueberry grows wild in the Southeast in river valleys and at the edge of woods. It is less sensitive to soil acidity and more resistant to heat and drought than the highbush blueberry. Commercial fields have been propagated from selected rather high-quality wild plants; total acreage is about 3,500, but the market value of the fruit is not known. The small black wild berries are sometimes of poor quality and coarse texture, receiving poor reception on the market. Propagation is by suckers or off-shoots arising near parent plants, although propagation from winter and summer cuttings, as for the highbush blueberry, is becoming increasingly popular. Cuttings are grown one year in the nursery before planting to the field in midwinter at a distance of 15 by 15 feet. Young plants grow rapidly and bear heavy crops beginning the third year. They respond well to mulching, cultivation and fertilization, and are pruned relatively little, although pruning as practiced for the highbush blueberry is desirable. Plants may bear an average of nine quarts, reaching 30 quarts in some years. Picking in Florida begins in May, the fruit ripening for some varieties over a 30-day period, although others may ripen over a three-month period extending into September. Rabbiteye fruit withstand shipment well. Leading varieties selected from the wild are Black Giant, Hagwood, Owens, and Myers. Other less promising named varieties are Ruby, Mineola, Sapp Early, Anne, Scott, Jean, Locke, and Okaloosa.

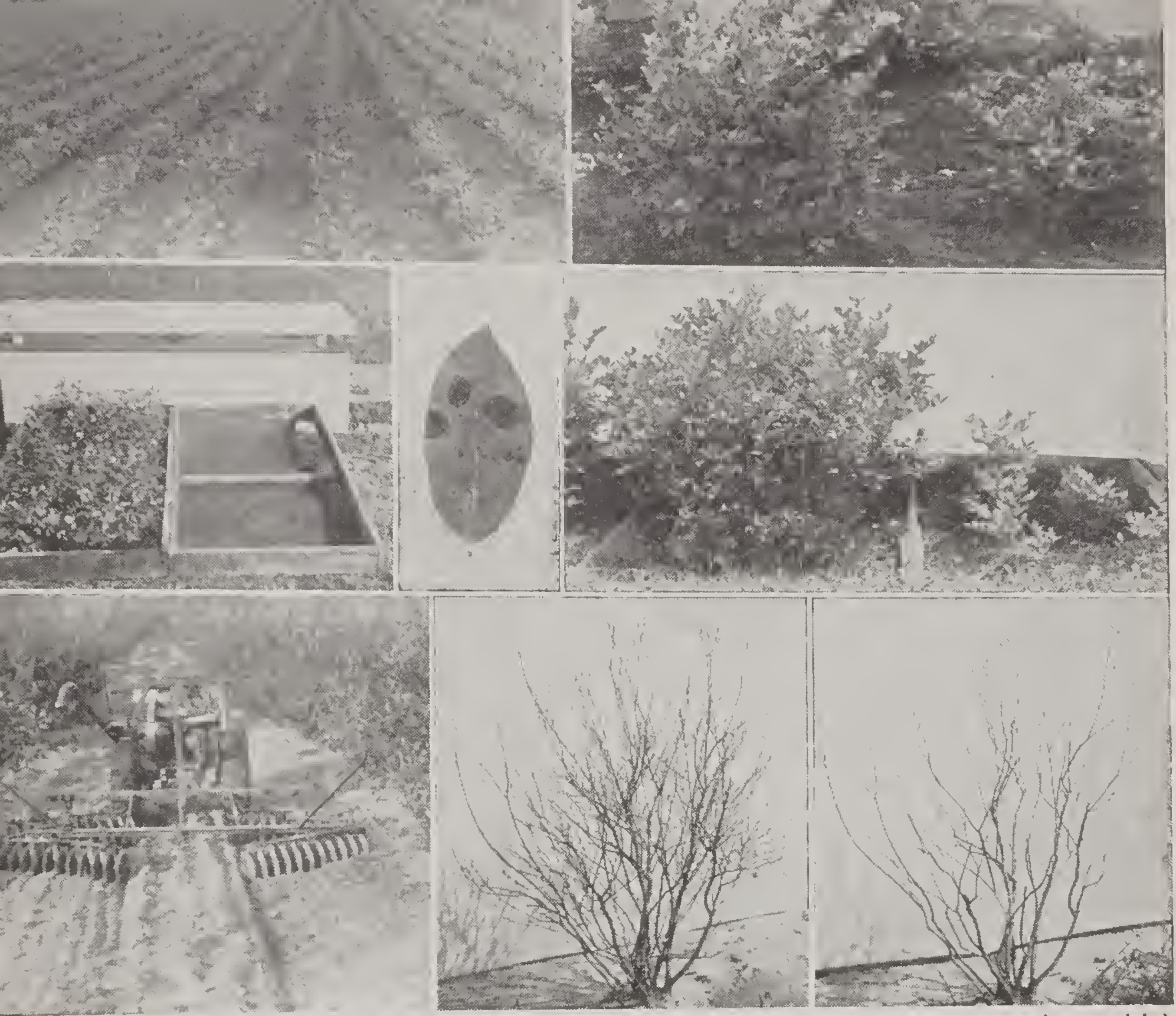
Climate and soil. The cold requirement of the highbush blueberry is similar to that of the Elberta peach. It possibly demands a slightly longer cold period than found in North Carolina, since this blueberry performs somewhat better in southern Michigan and the New England states. It may be killed by temperatures of —20° F. or lower, but a blanket of snow and sites with good air drainage reduce this danger. The highbush blueberry grows best in a more or less continuously moist soil with a pH between 4.3 and 4.8. Acidity should be raised or lowered to within this range by additions, respectively, of either lime or sulfur. It requires about a ton of lime per acre to raise the pH a half to one point, or, according to studies in New York, about 530 pounds of sulfur per acre to lower the pH one point on sandy soils and 650 to 1100 pounds on medium loams. Sulfur should be used on the more fertile loams to lower pH while ammonium sulfate serves the purpose better on sandy or poor soils where it also furnishes needed nitrogen.

Varieties. Rubel is by far the leading commercial blueberry variety. All other varieties now cultivated were bred by Dr. F. V. Coville. Of 18 of his promising varieties, the following lead in the United States in 1940: Cabot (early), 15.0 per cent; Rancocas (midseason), 12 per cent; Pioneer (midseason), 11 per cent; Jersey (late), 9 per cent; Concord (midseason), 9 per cent; Stanley (midseason), 5 per cent; June (very early), 2.5 per cent; and Scammell (midseason), 2 per cent. Among the minor varieties were Weymouth, Atlantic, and Pemberton, each consisting of less than 0.5 per cent of the total acreage. Cabot is losing popularity because the bush is susceptible to stunt disease, stem canker and mite; the fruit cracks badly in wet weather, is of poor quality except north of New Jersey, and runs small toward the end of a long season.

The following varieties are suggested for different regions. In New Jersey, Weymouth or June are desirable for early season, Rancocas for midseason, and Dixi, Atlantic, Pemberton, or Jersey for late season. In North Carolina, Weymouth or June are suggested for early season, and Rancocas for midseason. In Michigan and New England, Pioneer and Rubel are standard sorts, with Jersey and Atlantic promising varieties. In Michigan, however, Stanley and Jersey, respectively, are good as midseason and late varieties; early varieties are undesirable in this state. In New England, Weymouth for early, Pioneer for midseason, and Jersey for late are suggested for testing. Wareham ripens still later than Jersey and is worth considering as a very late sort. In western Oregon and Washington, Pioneer, Stanley, and Jersey succeed.

Berries of a given variety attain higher flavor if the nights are cool during the ripening season; thus, as one would expect, flavor seems to be generally better in the northern regions.

Although large solid blocks of Rubel and other standard varieties have



(Bottom left) C. A. Doehlert, New Jersey Agr. Exp. Sta., (Middle center, bottom center, bottom right) G. M. Darrow, U.S.D.A., (Others) Stanley Johnston, Michigan Agr. Exp. Sta.

Figure 298. (Top left) A blueberry nursery in Michigan. (Top right) Three-year Jersey blueberry bushes; left, a healthy plant; right, a plant with stunt disease (a virus). (Middle left) A low propagating frame with glass sash and burlap shade in place and two trays in front, one filled with root cuttings. Trays are placed in the top of the propagating frame and provide a convenient method for handling cuttings before they are sent to the nursery, shown in top left photo. (Middle center) Double spot is a serious leaf disease of cultivated high-bush blueberry in the South. (Middle right) Blueberries grow best in acid soil; the pH of soil on left is 4.87 and on the right, 6.08. (Bottom left) A New Jersey double-disk harrow drawn by garden tractor. Harrow will adjust itself to slope of ground. (Bottom center) Bush before pruning. (Bottom right) Four-year June blueberry after pruning. Buds were reduced by about 75 per cent. A much larger number of buds may be left on plants in very fertile soil.

yielded well in Michigan, it is generally recommended that two varieties be grown near each other to insure cross-pollination and good production.

Propagation. Although some wild highbush blueberries are being fertilized, sprayed and pruned, it is becoming increasingly desirable to propagate and cultivate the selected varieties for good yields of high-quality fruit. The blueberry can be propagated by hardwood or softwood cuttings, but exacting procedure is necessary for good results. Commercial propagation is done almost entirely by hardwood cuttings. In early spring, medium to medium-large hardwood cuttings, four to six inches long and selected from dormant shoots of the previous season's growth, are cut just below a bud at the base and just above a bud at the top; winter-injured wood or wood with fruit buds should be avoided. The cuttings may be rooted in ground beds with lath shade seven and one-half feet above the ground, or, in special covered frames. A mixture of peat and sand, half and half, to a depth of six inches is used in the ground beds. The covered frame, as shown in Figure 298, is constructed 6 feet by 27 inches by 16 to 40 inches deep; it contains a tray four inches deep with a one-quarter-inch mesh hardware cloth bottom which rests on cleats about ten inches below the top of the frame. Cuttings are placed slanting about one inch apart in rows two inches apart in a peat medium. Coarse burlap about the texture of bran sacks may be used over the glass sash for shading the cuttings. Check the cuttings once every day or two to remove any dying cuttings and thus remove the source for fungus spread. The tray system of propagation has the advantage of being easily transported to the nursery row when the cuttings are ready to transplant.

Although the cuttings root by June, they are left in the ground beds or trays until the following spring. The shade is gradually removed with increased waterings until about September when the tray is sunk into the soil to ground level on a well-drained spot; it is protected from animals by a wire cloth over the top.

Cuttings are set in the nursery six to ten inches apart in rows 18 or more inches apart and grown for a year, as shown in Figure 298. They are sold as two-year plants. In the permanent location, plants are set one to two inches deeper than they grew in the nursery at a distance of four by ten feet when standard tractors are used in cultivation. A distance of five by eight feet is suggested where garden tractors will be used (Figure 298). Early spring planting is recommended, although in New Jersey blueberries are often planted in early fall; in North Carolina they may be planted in late fall or winter. Hand hoeing around the young plants is desirable.

Soil management. Shallow cultivation should be practiced until after harvest, when a locally suitable cover crop is sown. Spring oats and Sudan grass are frequently used in southern Michigan. Manure and leguminous mulch have been disastrous in some cases and should be avoided or thoroughly tested in small areas before generally used. Little or no fertilization may be needed on fertile soils, whereas poor soils may require large amounts for good yields. Nitrogen has shown the best response in New Jersey and North Carolina. Phosphorus, 670 pounds per acre, has given good results in Michigan, although 500 pounds per acre of a complete fertilizer has usually given better results. For sandy soils in Michigan, Stanley Johnston[1] suggests an 8–8–8 formula, with potash derived from sulfate of potash, because muriate of potash (KCl) has caused injury to young plants. A 3-9-18 formula is recommended for muck soils. One ounce per plant per year of age is suggested up to a maximum of eight ounces; more fertilizer might be used in rare instances. It is suggested that one application of 400 to 600 pounds per acre of a complete fertilizer, such as 5–10–5, be applied in spring when the buds start growth. If the soil is below pH 4.8, 150 pounds of nitrate of soda or calcium nitrate per acre should be applied six weeks later; or, if the soil is a little above pH 4.8, about 110 pounds per acre of sulfate of ammonia should be used. On poor soils, this is followed by one or possibly two similar applications at six-week intervals. Magnesium and minor elements may be needed on poor sandy soils. Where heavy mulches are used, more nitrogen should be applied, using instead 300 pounds per acre per application. The fertilizer is broadcast in the root zone six to twelve inches from the plants.

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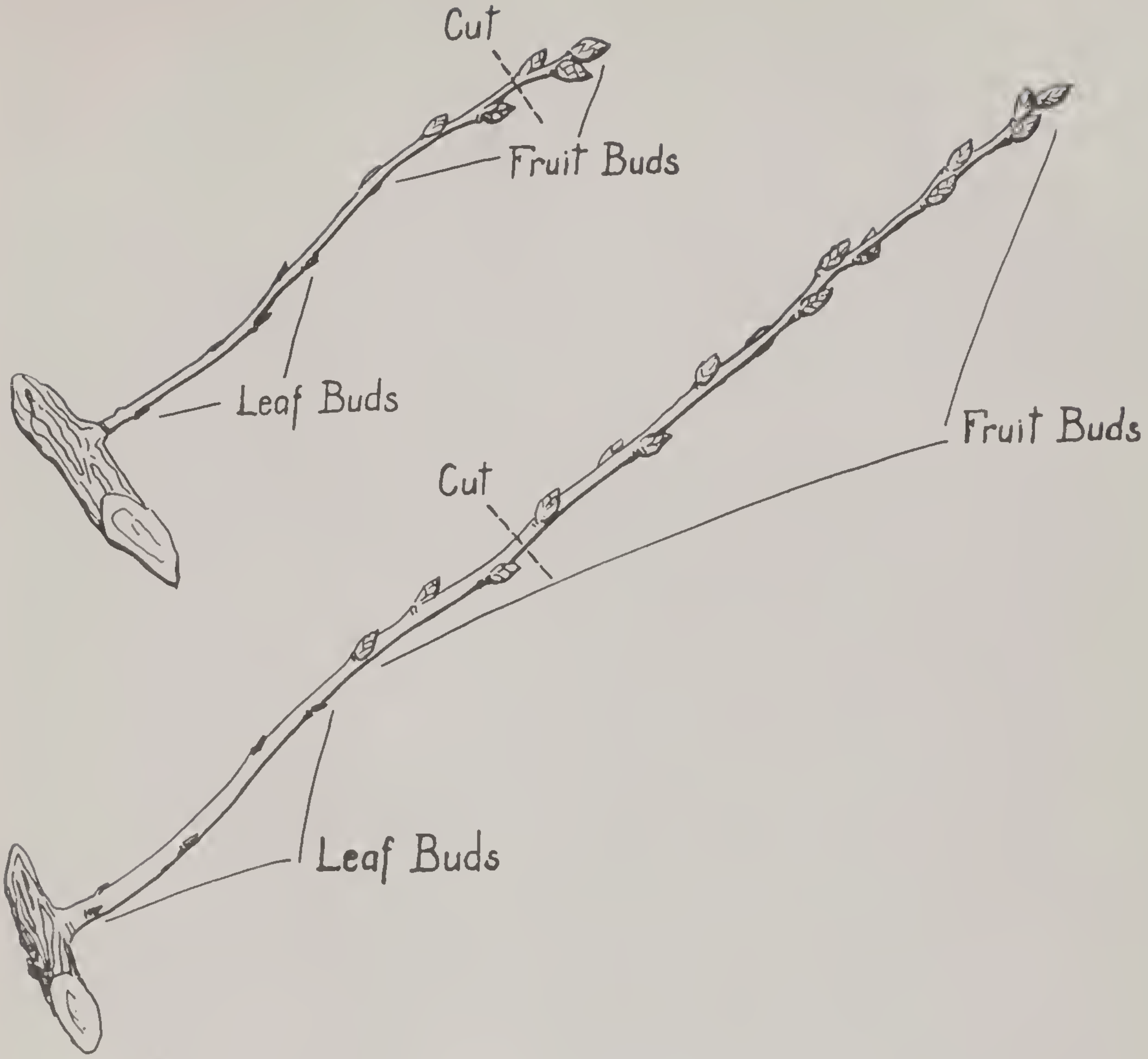
[1] By correspondence.

Moist soils are essential but the water table should not come higher than within about 18 inches of the surface. On low wet areas, tile or ditches of the proper depth will carry away excess water rapidly. The plants can be set on ridges in the low spots. If drought periods are a problem, mulching with sawdust six to eight inches deep is suggested; straw mulch requires the utmost precaution against fire. Furrow and sprinkler irrigation is practiced in North Carolina, applying one to two acre-inches at ten-day intervals during the picking season and possibly one or two applications later if needed.

Pruning blueberries. The blueberry bears fruit on wood of the previous season's growth, beginning the second year after planting. The largest and best berries are borne on the more vigorous wood. Inasmuch as most varieties tend to overbear, it becomes necessary to thin the bushes and prune off some of the excessive buds. Varieties, such as Cabot and Pioneer, which develop spreading bushes need more attention in removing the lower drooping branches, whereas upright growing varieties such as Rancocas, June, Rubel, Concord, and Scammell need more thinning at the center. Light pruning is suggested as a general rule. Heavy pruning, consisting of thinning the small branches, cutting out some old stems, and rather heavy heading back of clusters is reported in Michigan to reduce the crop considerably, increase the size of the berries, and hasten ripening. The later-ripening somewhat smaller berries on lightly pruned bushes are desired in Michigan because they bring better prices as a result of less competition from wild blueberries and such fruits as raspberries, strawberries, and cherries. Heavy pruning should rarely be practiced under any condition.

Vigorous plants are able to carry a large crop of fruit and, therefore, should receive less pruning, provided soil moisture is adequate at all times. Somewhat more pruning is necessary on less vigorous plants growing on soils low in fertility and occasionally deficient in soil moisture.

No pruning is needed until after the third growing season when only the bushy growth is removed at the base of the plants. After the fourth season, remove the dead and broken branches. Confine the pruning as much as possible to a few large cuts in order to save labor, removing clusters of very thin bushy wood that tend to accumulate in mature bushes. Old stems which have lost their vigor and become very bushy may be removed at the ground, or, sometimes it is possible to cut them back to a vigorous side shoot. Branches drooping close to the ground should be removed. Concord, Rubel, and Rancocas bushes are more expensive to prune, because they require



C. A. Doehlert, New Jersey Agr. Exp. Sta.

Figure 299. (Top) Lateral sprout of Cabot blueberry and (bottom) Sam showing amount of trimming back needed for these varieties during pruning.

more thinning out of the small branches.

The fruiting shoots of varieties such as Cabot, Scammell, Pioneer, and Sam should be cut back to three to five fruit buds per shoot to increase berry size (Figure 299). Amount of cutting back varies with the number of fruit buds per shoot as influenced by growing conditions and variety. Varieties which require very little cutting back are Rancocas, Concord, Stanley, Jersey, Rubel, June, and Weymouth. The shoots should be cut back only after danger of winter injury is past.

Cost of pruning can be reduced and the job simplified by using lopping shears for the majority of the cuts. Pruning can be performed any time after the leaves drop until slightly after blossoming if necessary.

Harvesting and marketing. The harvesting season begins about May 20 for North Carolina, June 20 for New Jersey, and July 10 for southern Michigan. Varieties grown in North Carolina are the early to midseason sorts, in New Jersey the midseason to late varieties, and in Michigan, the very late varieties. The picking season for any district may extend over a period of six to eight weeks, including early to late-ripening varieties. Three to

seven pickings are made at five- to seven-day intervals, depending upon the variety and weather. Blueberries hang on the bushes well and are not so perishable as raspberries. Only ripe berries are picked, since those having a reddish tinge are sour. Berries are picked directly into tightly constructed pint boxes (Figure 300) in New Jersey, while in Michigan, small pails are used. Although some bloom is destroyed by more handling with the pails, the berries can be inspected and the leaves and green berries removed as they are gently poured from the pail into the pint boxes. If the crop is heavy, one picker can harvest from 60 to 80 pints in an eight-hour day. The crop is mostly packed and marketed by co-operatives and the berries are sold according to size grades, the larger the berry the higher the price. The grades in Michigan are as follows: Superior—85 or fewer berries in a measuring cup; Golden Moon—86 to 130 berries; Columbia—131 to 190 berries; and Lake State—all marketable berries more than 190 to a measuring cup. Grading and sizing machines are coming into use, especially with the wild berries which may show more variation in size and grade than the named cultivated varieties. In Michigan, occasional sample cups of standard varieties are checked for number of berries; experienced men can estimate berry size almost at a glance. Cellophane-wrapped boxes (Figure 300) increase the attractiveness and holding period of the berries. A rubber band or a piece of sticker tape is used to hold the cellophane in place.

Michigan yields on good soils will run from the second to sixth year, respectively, 50, 200, 2050, 4000, and 6000 pints per acre. A mature plant will bear an average of six to eight pints, but with proper soil management and pruning, it may produce 20 pints.

Most cultivated blueberries are marketed fresh, but increasing quantities are being frozen and canned. Frozen with or without a 50 per cent sugar solution, the berries are used in pies or eaten with cream. Frozen berries are almost as good as fresh berries and superior to the canned ones; frozen Pioneer, Cabot, and Concord have better flavor than Rancocas and Rubel. The texture and flavor is much better when frozen in a heavy sirup (Chapter XVIII). Blueberries are high in vitamin C.

Diseases and insects. *Stunt virus disease* (Figure 298) may appear on such susceptible varieties as Cabot, Pioneer, Concord, and Scammell in New Jersey and North Carolina and to a lesser extent in New York and Michigan. Rancocas is highly resistant. Rogue the infested bushes. *Mummy berry* is an erratic fungus disease blighting blossoms and new shoot tips; mummified

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Figure 300. Harvesting Blueberries. (Top left) School children and instructors, as supervisors, are transported in early morning for blueberry picking. (Top right) Pint picking-baskets are fastened to the belt. (Middle left) Harvesting scene at Whitesbog, New Jersey, in July. (Top middle right) Elizabeth C. White, New Jersey pioneer in blueberry varieties and large commercial producer. (Bottom middle right) Twelve-pint trays are inspected by forewoman for any green and damaged berries; picker's card is punched if berries are satisfactory. (Bottom left) Most blueberries are marketed in 16-pint crates and may be shipped long distances under refrigeration. Cellophane improves appearance and prolongs keeping. (Bottom right) Branch showing fruiting habit of blueberries.

berries stick to the bush. The Michigan Experiment Station recommends shallow plowing as early in the spring as possible (March or April) particularly in spots where infection has been severe. Then remove mummified berries from plant crowns and thoroughly hoe between plants. Cultivate at weekly intervals until after bloom. *Phomopsis twig blight* is usually not serious, entering fast-growing shoots causing them to wilt. Remove blighted wood during pruning. *Stem canker* results in extensive cankers and blisters on susceptible varieties in the South. Rubel, Jersey, and Scammell show resistance, with Rancocas highly resistant. Use resistant varieties if disease becomes a problem. *Double spot* (Figure 298) may become serious in North Carolina, resulting in considerable defoliation in some years. Concord, June, Stanley, Rubel, and Weymouth show resistance. A 4–4–50 bordeaux is effective control, using three applications starting after the blossoming period; second application is made after harvest, followed by another 30 days later.

Blueberry maggot (of the fruit fly) is the most serious insect, causing entire shipments to be condemned because of wormy berries. Airplane or power dusting with 10 to 15 pounds per acre of 5 per cent rotenone is often used in New Jersey when adult flies first appear in numbers, but before egg laying starts, followed by a second application ten days later. *Cranberry fruit worms* (and other fruit worms) cause relatively unimportant fruit damage, but a few of these worms crawling over the fruit under cellophane packs is unsightly. Pyrethrum dust, 30 pounds per acre, applied by airplane about May 29 in New Jersey and again a week later is practiced. *Cranberry weevil* may damage or destroy the blossoms, reducing the crop 50 per cent in some areas. Arsenate of lead, three pounds to 50 gallons, applied over the field, between leaf-bud swelling and flower opening is suggested. Other insects of lesser importance include the blueberry bud worm, forest tent caterpillar, fall webworm, Tatana worm, and leaf rollers, blueberry mite, scale insects, stem gall, stem borer, and cranberry root worm. For detailed descriptions and controls, contact your local experiment station or see bulletin by Darrow, Wilcox and Beckwith.

CURRANT AND GOOSEBERRY CULTURE

Currants and gooseberries grow best in the northern United States where conditions are relatively moist and cool. In the South, the summers are too long and hot, and often too dry, particularly in the Southwest. In the Pacific Northwest and in the region of Colorado and Utah, they may grow satisfactorily provided irrigation is available. The main area for commercial currant production is in a line from southern Michigan to the Hudson River Valley of New York. Other regions are around San Francisco, the Willamette Valley of Oregon, and the Puget Sound in Washington.

Currants and gooseberries are extremely resistant to low temperature and with windbreaks will even survive in the northern Great Plains area. Gooseberries can be grown somewhat farther south than currants because they are more resistant to heat. The limits of currant and gooseberry growing can be extended or altered somewhat by higher altitudes or provision for irrigation.

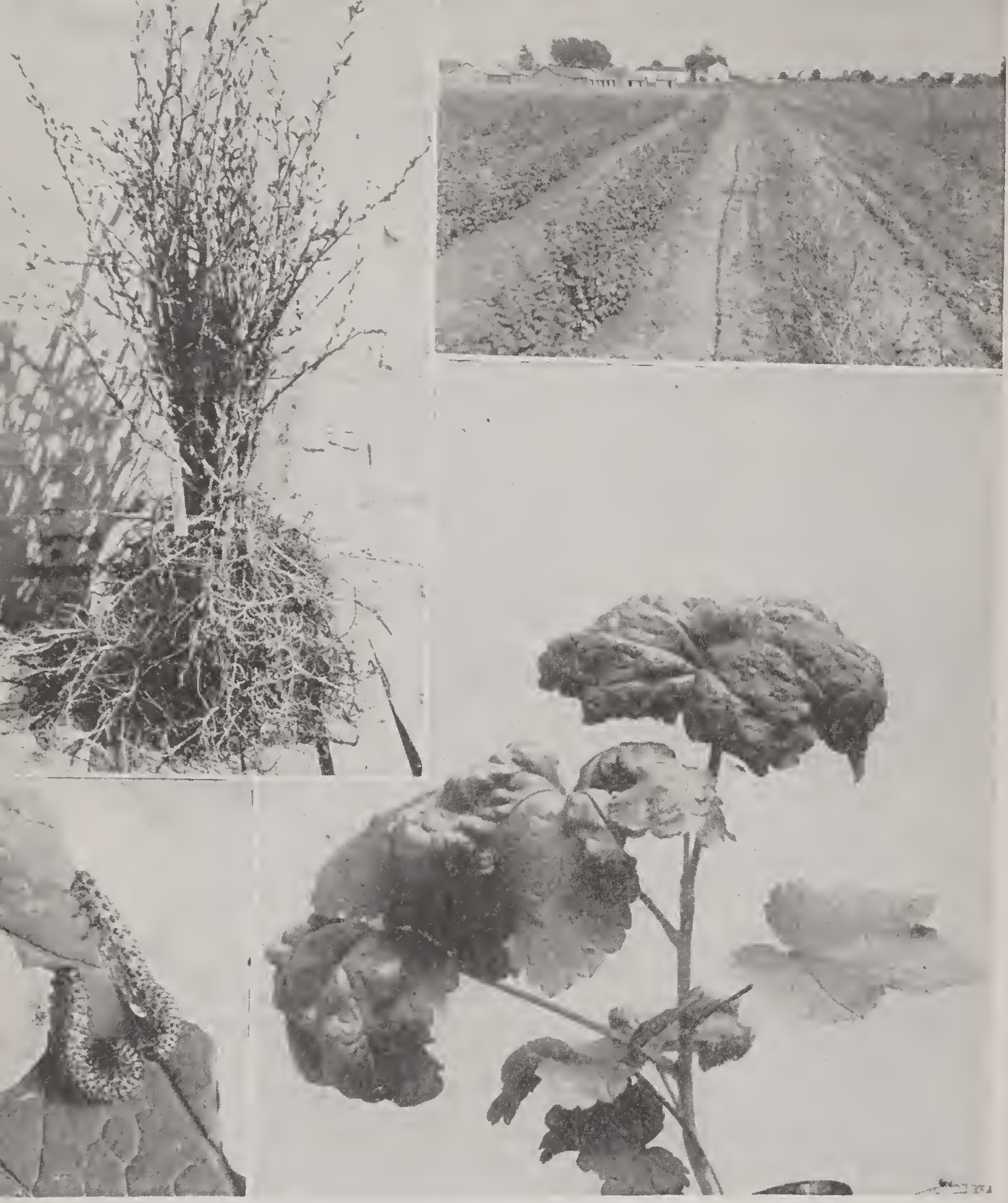
Four main factors limit production of currants and gooseberries in the United States; namely, summer heat, lack of adequate soil moisture, the currant maggot for which there is no control, and the white-pine blister rust. Before making a commercial or home planting of currants or gooseberries, the nursery inspection department of the local state department of agriculture should be consulted. The reason for this is because gooseberries and currants, particularly the black currants, are alternate hosts to the white-pine blister rust which is a very destructive disease of the five-leaf pines. If currants and gooseberries are destroyed in regions where the white pine is grown, the disease is checked. Obviously, the value of the white pine crop far exceeds that of the currant or gooseberry. All citizens should co-operate in this program.

Varieties. Most desirable currants are the red varieties which have an erect vigorous growth habit, are easy to cultivate and pick, and have large-sized firm compact clusters. Following varieties are recommended in the United States: Red Lake, Perfection, Wilder, Red Cross, and White Imperial for northeastern part; London Market, Wilder, Red Cross, Red Lake, and Perfection for Michigan and the Middlewest; and Perfection, London Market, Red Cross, Wilder, Fay, and Victoria for the Pacific Coast. Red Lake is tops in some regions and increasing in popularity in others. White and black currants receive limited attention because of color and the peculiar flavor of the blacks; the black currant also is highly susceptible to the white-pine blister rust. This rust disease may be largely responsible for the more than 50 per cent reduction in currant acreage since 1929; present commercial acreage is less than 2000.

American varieties of gooseberries are most desired because they are more productive, hardier, and have better quality. European varieties are larger and sell better, but are more susceptible to mildew. The Poorman is widely planted in the North; Glenndale succeeds in Virginia, Tennessee, and Arkansas. Abundance, Perry, and Pixwell are recommended in the region of North Dakota. All of these are full or part American parentage.

Establishing the plantation. Currants and gooseberries bloom very early in spring. Northern exposures are desirable, especially in the southern extensions of the industry. Air drainage and circulation are important against frost damage and also for disease control, especially with gooseberries. A deep fertile loam retentive of moisture is the best soil.

Currants and gooseberries should follow a cultivated crop, if possible; plow and disk the soil well, and add manure and fertilizer as recommended for raspberries. Fall planting is suggested for most areas because these fruits start growth so early in the spring. Spring planting is suggested in the northcentral area, in which case fall plowing is desirable.



(Top right) New York Agr. Exp. Sta., (Others) G. M. Darrow, U.S.D.A.

Figure 301. (Top left) Bundle of 27 vigorous gooseberry plants (currants are similar) as received from nursery. (Top right) Left rows in the currant plantation were sprayed with bordeaux mixture with sticker-spreader for leaf spot; right rows unsprayed. (Bottom left) Imported currant worm may cause serious damage. (Bottom right) Curling of leaves caused by currant aphid on underside.

The nursery is probably the best source for plants; they are shipped as one- or two-year plants in bundles of about 25 (Figure 301). If a grower desires to extend his planting of a preferred variety, this may be done by cuttings. Eight-inch cuttings from one-year wood are selected any time during the dormant season. They are tied in bundles of a dozen and placed base up in a box of moist sand or peat in a cool basement. In early spring, cuttings are set to the garden or nursery at a depth of six inches with a spacing of six inches in rows three feet apart. Gooseberries can be propagated by bending branches downward in the fall and partly covering them with soil.

Gooseberries and currants also can be propagated by mound layerage; from 50 to 100 rooted cuttings can be obtained from a single plant. All branches are cut off about three inches aboveground in early spring. In July, soil is mounded around the vigorous shoots, covering half their length. The rooted shoots are removed in fall or spring and set to the nursery for one year before planting permanently in the field.

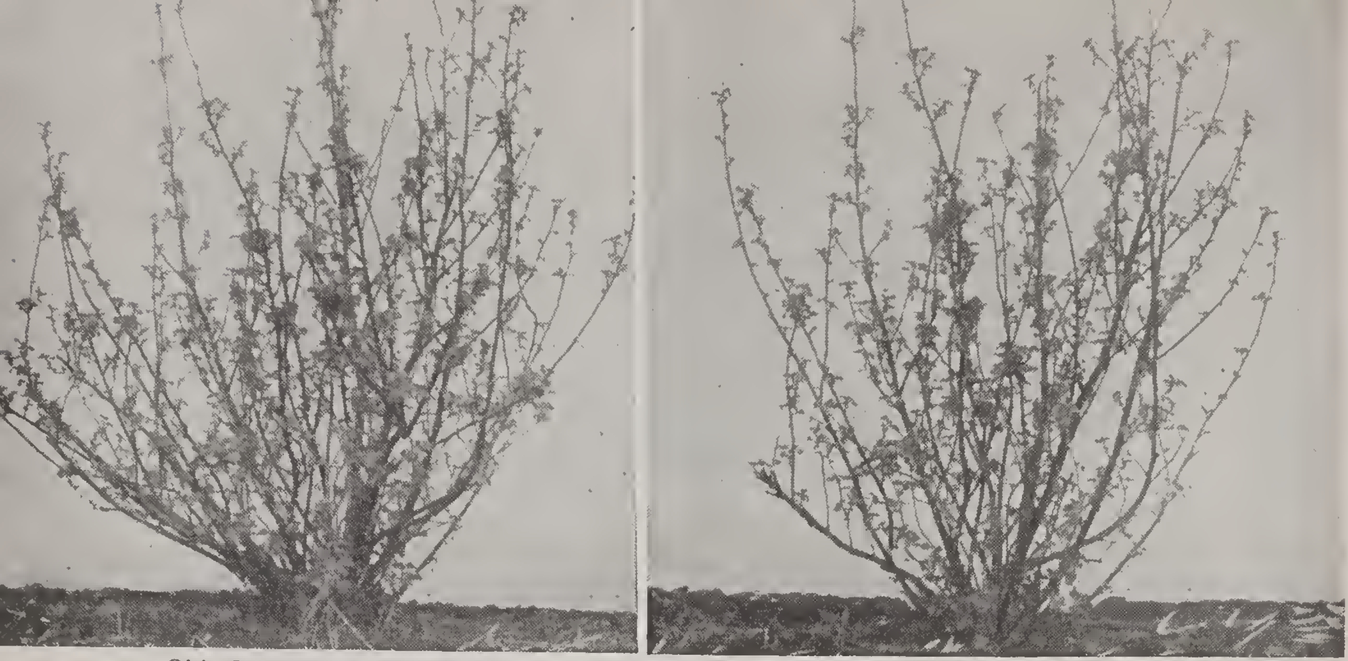
These fruits are set four to five feet apart in rows five to ten feet apart, depending upon cultivation equipment available. In planting, damaged roots are removed, the branches cut back to five inches, and the plants set with the lowest branches just below the ground surface in order to encourage a bushlike plant. Dig holes for each plant in heavy soil; in light soil, a shovel may be inserted and moved back and forth to form a V-shaped opening into which the plant is set.

In home gardens, currants can be planted between and in grape rows, but cultivation must be done either by hand or narrow machinery. Also, currants may be planted in tree rows, provided fertility and moisture are maintained sufficiently high for both crops.

Soil management. Frequent shallow cultivation should be practiced until shortly after picking when weeds are allowed to develop or a locally adapted cover crop is sown. These fruits respond well to a heavy mulch of straw or similar material. A double application of nitrogen fertilizer is needed with mulch to avoid nitrogen deficiency. A mouse poisoning program is necessary with mulching practice (Chapter V). No winter protection is needed, except perhaps to tie the bush in a bunch to prevent breakage from ice and snow.

Currants and gooseberries respond well to a fertile soil and to additions of manure at the rate of 10 to 20 tons per acre. In the absence of manure, apply 200 pounds per acre of ammonium sulfate or nitrate of soda, or 150 pounds of ammonium nitrate. The manure or fertilizer should be applied as a side dressing early in spring about two or three weeks before growth starts. In the light sandy soils, it may be worthwhile to establish small fertilizer test blocks, using nitrogen, phosphorus, and potassium applied alone or in combinations.

Pruning. Plants are pruned to a bush form, varying in height from three to five feet. Best fruit with currants is produced on spurs of two- and three-year wood, although some fruit is borne near the base of one-year canes. Older wood produces inferior fruit. Prune in early spring before the buds begin to swell. The object is to remove branches over three years of age and, by thinning, select the proper kind and number of canes and branches to maintain a productive bush. Age of the wood can be judged by counting back annual growth rings from the tip (note change in color of bark and



Ohio State University Agr. Ext. Serv.

Figure 302. (Left) A Red Lake currant before pruning. (Right) After pruning. Tall growth was cut back; low horizontal branches and most of wood older than 3 years was eliminated. One-year canes were thinned to three or four vigorous canes.

character of growth for each year). After pruning, the well-pruned dormant bush will have about three upright growths each of three-, two-, and one-year wood. With mature vigorous bushes, a few more upright growths of each age can be left (Figure 302). Thin the surplus slender weak wood. Branches growing horizontal and close to the ground should be removed to avoid dirty fruit.

Gooseberries are often pruned similarly to currants, although they tend to bear heavier on one-year canes than do currants. Thus, the wood is sometimes removed after it is about two years old, or after it has borne a year from spurs.

Insects and diseases. *San Jose scale* appears as grayish crust formations on the older growth, resulting in a yellowish unthrifty dying condition. The *imported currant worm* (Figure 301) may appear shortly after the leaves expand in spring and destroy almost the entire foliage in a day or so. *Currant aphid* (Figure 301) attacks undersides of leaves, causing them to curl. In order to hit aphids, spray should be applied before leaf curling is pronounced. *Currant fruit fly* or *maggot* is destructive to the berries, particularly in the West and Canada; no control is known. *Leaf spot* may result in defoliation (Figure 301), the leaves falling during mid- to late season, reducing production the following year. *Anthracnose* appears as numerous small brown spots on upper leaf surface, causing foliage to turn yellow and drop. Other diseases include cane wilt, white-pine blister rust, and powdery mildew which is particularly destructive on gooseberries.

Harvesting and marketing. Currants for jelly should be picked slightly underripe when the pectin content is high. Currants can be picked fully ripe over a long period of time if they are to be stewed, spiced, or used in jams. For the market, they should be picked with extreme care when an occasional berry on each bunch is slightly green. Pinch off the main cluster stem at the base, using the forefinger and thumb. Do not crush the berries. Injured berries exude juice which collects dust and dirt and may develop mold quickly, especially if they are held shortly under damp conditions. Currants can be stored for a short time under cool dry ventilated conditions.

Gooseberries are mostly picked green at maximum size; harvesting may extend over a period of four to six weeks. For processing, berries can be stripped from the bushes with a cranberry scoop or heavy gloves, later separating the leaves by a grain-fanning mill. Gooseberries for the general market must be picked carefully to prevent injury and spoilage. Keep gooseberries in the shade to prevent sunscald. They can be held in storage much longer than currants.

Both gooseberries and currants are marketed in 24- and 32-quart crates; they are rarely handled in pint baskets. For the canner, six- to eight-pound grape baskets are standard.

Yields may average 100 bushels per acre for European gooseberries, and 300 bushels per acre for varieties of American or partly American parentage. Gooseberry bushes yield somewhat more than currants, the latter of which may produce five to ten quarts each.

CRANBERRY CULTURE[1]

The cranberry is native to North America. It is largely consumed in the United States and Canada with but few exports. Cranberry growing is a highly specialized industry confined to acid bog or swamp areas and, thus, limited to only a few states. Massachusetts produces over half of the world's supply, bringing the state $5,000,000 or more in good years. The 1937–46 average production for the United States as a whole was 673,940 barrels. The 1946 crop reached 856,100 barrels. The leading states on a ten-year average were Massachusetts, 445,600 barrels; Wisconsin, 105,800; New Jersey, 86,100; Washington, 26,710 and Oregon, 9,730. Scattered fields occur in Maine, New Hampshire, Rhode Island, Connecticut, Virginia, Minnesota, Michigan, and Long Island. Total acres involved in cranberry growing, including water reservoirs and sand banks, may exceed 70,000; the U. S. Census of 1939 showed 18,000 acres actually planted to commercial cranberries which was an increase of 50 per cent over 1929.

Several factors should be considered before developing a cranberry swamp or bog. It costs from $500 to $1,500 per acre to clear and properly level and ditch the bog, install water pumping systems and dams, and to make the planting. From $200 to $400 are required for upkeep the first three years before the crop comes into bearing. Alkaline peat and ordinary garden and farm soils are not suitable. A large supply of water is needed for irrigation and flooding for protection against winter injury, untimely frosts, and insects. The site must permit drainage of the bog to a depth of 18 inches. A large supply of readily available clean sand is necessary. A climate, such as near

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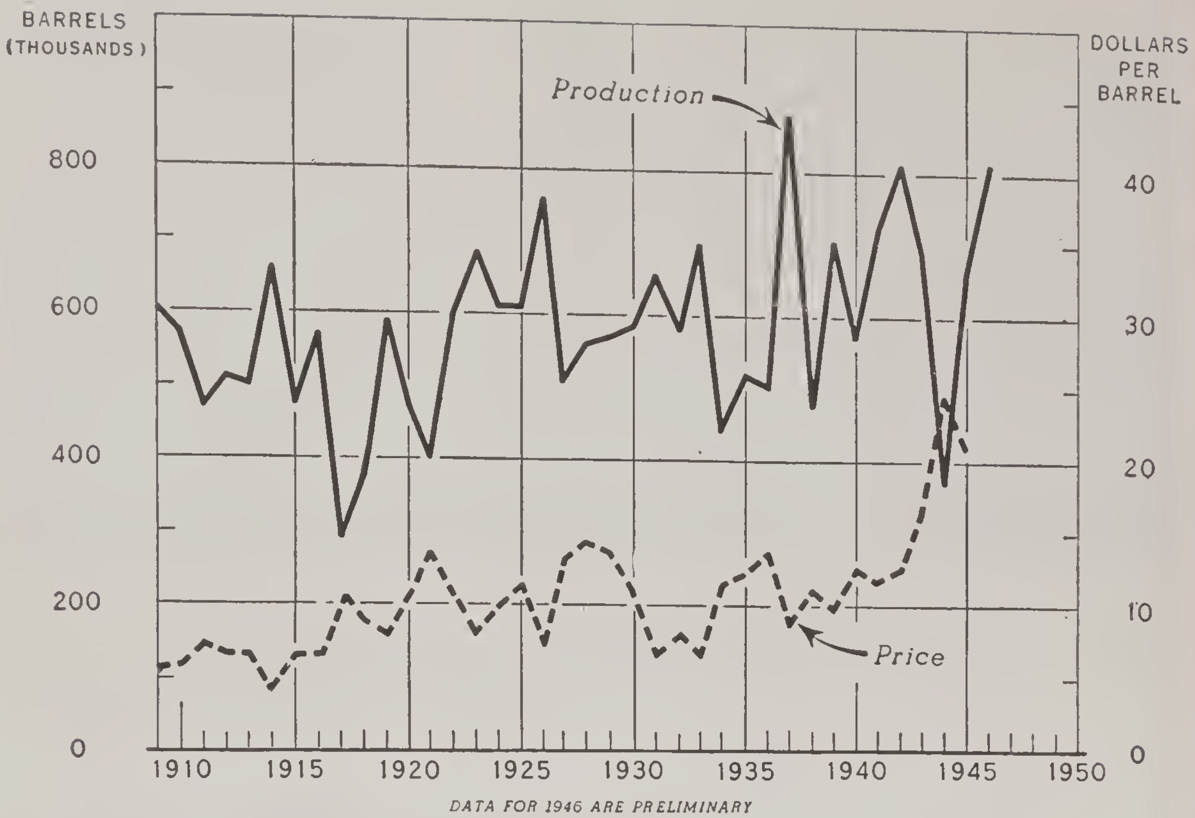
[1] Space permits only a brief discussion. See suggested collateral readings for details.

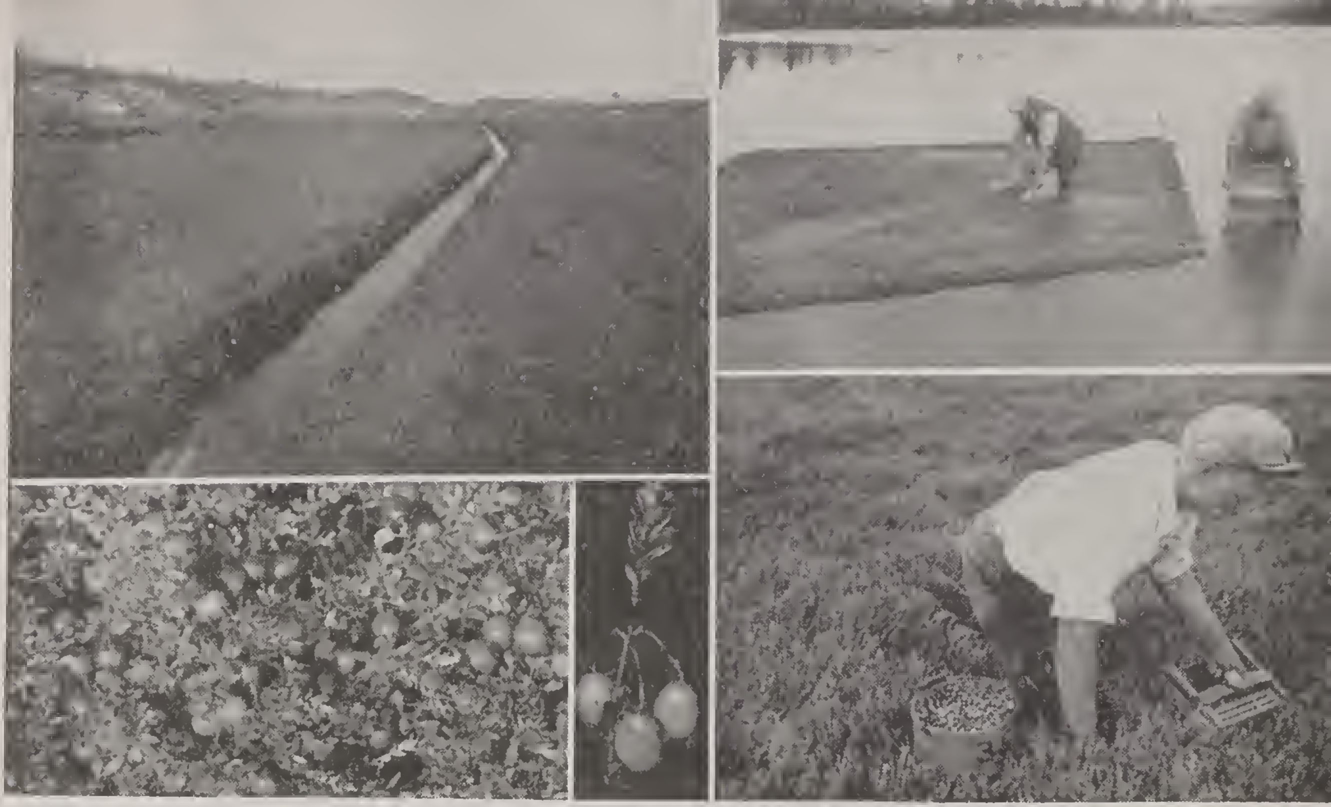


U.S.D.A. Bureau of Agricultural Economics

Figure 303. The trend in production of cranberries and average price received by farmers has been gradually upward since 1909. Sharp rise in prices in 1943 was due to short supply and a heavy wartime demand.

Cape Cod, Massachusetts, and in Wisconsin is most desirable. A climate warmer than New Jersey induces more berry rotting and disease problems. Cranberry growing north of Nova Scotia is limited because the summers are too short and too cool. Cloudy weather during ripening, such as frequently occurs in Washington and Oregon, results in uneven maturity of berries. To establish cranberry fields in new sections, it requires years of work to develop new varieties, to train local people in the business, and to learn the peculiarities of the industry.

A good bog site for cranberry growing is shown in Figure 304. Long narrow bogs are the most desirable with adequate air circulation on all sides, good sun exposure, and with potentialities of quick flooding and quick drainage of the field. Steps involved in the preparation of the field include: (1) clearing the field of trees and brush, (2) cutting the turf into squares, turning them over, and removing and burning roots of all weeds and obnoxious plants, (3) construction of ditches around and through the field, (4) grading the field level to facilitate quick flooding and drainage, (5) construction of dams for sectional flooding of the field if it is large or the grade is relatively marked, (6) construction of flood gates and installation of pumping equipment, (7) covering the field with three to four inches of white coarse sand free of small stones, (8) planting the cuttings in the early spring about a foot apart both ways, and (9) flooding the bog for a day or so immediately after planting.



Henry J. Franklin, Massachusetts Agr. Exp. Sta. and American Cranberry Exchange

Figure 304. (Top left) A long, narrow, well-kept cranberry bog on Cape Cod, Mass., showing proper grading and ditching and the sand supply banks on either side. (Top right) After harvest, field is flooded, floater berries assembled with planks, and gathered for canneries. (Bottom left) A view of Early Black cranberries ready for harvest. (Bottom center) An upright branch showing how berries are borne. (Bottom right) Picking with a "snap" machine in young planting. Larger two-hand cranberry scoops are frequently used, holding one-half bushel.

Leading varieties in Massachusetts are Early Black and Howes; in New Jersey, the Jersey, Howes, and Early Black; in Wisconsin, the McFarlin, Searl, and "Natives"; and in Washington and Oregon, the McFarlin which comprises most of the crop.

Special attention to weeding is necessary for the first three years until the vines cover the ground. The bog is flooded only enough to cover the vines when the ground begins to freeze each fall; it is drained about April 1 in most years in Massachusetts, but may be left several weeks later if certain insects are a problem. Short floodings may be necessary during the early fruiting year for protection against frosts. Frost protection is being provided in some bogs with rotating sprinklers and overhead irrigation systems. Flooding is also timed during the early season to kill injurious insects, and is used occasionally for irrigation purposes during summer droughts. Most bogs are resanded once every year or two, adding a one-quarter to one-inch layer for protection against frost, the girdler insect, the green spanworm, and the tip worm. This is done by hand from special wheelbarrows, or by dump trucks on the ice while the bog is frozen over.

No fertilizer is usually needed for peat-bottom bogs unless growth becomes poor. Nitrate of soda and superphosphate are recommended on bogs in Massachusetts with sand or clay underneath, using 150 and 300 pounds per acre, respectively, applied when the vines are beginning to bloom in late spring. In New Jersey, 500 pounds per acre of the following mixture are used on Savannah land: calcium nitrate, 75 pounds; dried blood, 75; rock phosphate, 300; and sulfate of potash, 50. Manures are likely to contain weed seed. Weeds may be removed with special hand tools or certain weeds may be killed by applying such herbicides as water-white kerosene, sodium arsenite, copper sulfate, and others.

Berries may be harvested with the fingers, with hand scoops or by special motor-driven harvesting machines. A foreman, 13 scoopers, and two helpers are needed in Massachusetts to harvest a 15-acre bog. Yields vary from 21 to 41 barrels an acre and well-managed bogs may reach an average of 50 barrels over a period of years. The field is flooded after harvest, and the floater berries are gathered and sold to the canneries (Figure 304). Floating runners after harvest are trimmed with a special knife-rake or pruner. On fertile bogs, the vines may need to be mowed if too deep and dense.

Cranberries can be stored in common storage in the screen house or in cold storage at 35° F., the latter being better. The berries first are sent through a separator which removes chaff, then directed over bounding boards to separate decayed from sound fruits, and finally over grading belts for hand grading. Cranberries are sold by the quarter-barrel box. Price per barrel varies from $4.50 to $13.00 and sometimes reaches $30.00. Almost a third of the crop is canned as sauce or made into beverages. Some cranberries are quick frozen. There has nearly always been a good demand for cranberries.

Diseases include *early rot* of the flowers, young berries, and stored berries and *false blossom* or rose bloom, a virus carried by the leafhopper. There are several troublesome insects. The *cranberry fruit worm* is sometimes found in a third of the crop; the *black-headed fireworm* feeds on the foliage; the *blunt-nosed leafhopper* carries false-blossom virus; the *root grub* causes dead spots over the field; the *gypsy moth* feeds on the foliage; and the *girdler* weakens or destroys plants by feeding on the underside of runners. The false army worm, brown spanworm, and other insects may become troublesome at times. For detail control measures, see references at the end of this chapter and your local experiment station.

Well-managed cranberry fields are practically permanent.

Review Questions

BRAMBLES

1. To what regions of the United States are the following brambles commercially adapted: red, black, and purple raspberries, blackberries, dewberries, and loganberries?
2. Describe a suitable site and soil for red raspberries.
3. State briefly how the following brambles are propagated: red, black, and purple raspberries, blackberries, and dewberries.
4. How do the three main planting systems for brambles differ and to what brambles are each particularly adapted?
5. Outline a good soil management program for red raspberries in your locality. Would you include irrigation and, if so, why?

6. Which brambles are summer pinched and why?
7. How does dormant pruning of black raspberries differ from that for red raspberries?
8. When are trellises desirable for red raspberries and for blackberries?
9. How does dormant pruning for the upright blackberry differ from that for the trailing blackberry and dewberry?
10. Differentiate between anthracnose and a virus disease of raspberries.
11. At what stage of maturity should raspberries, blackberries, and dewberries be picked?
12. What yield could you expect from a well-managed blackberry, dewberry, and red, black, and purple raspberry plantation?
13. For what brambles and in what regions is winter protection advisable? How is it provided?

BLUEBERRIES

14. What are the leading states in cultivated blueberry production?
15. Which of the blueberries are propagated for cultivation, and which is the most important commercially?
16. What are the climatic and soil requirements of the highbush blueberry?
17. List three leading varieties of the highbush blueberry.
18. How are blueberries propagated?
19. Outline a soil management program for a young and mature commercial planting of blueberries on a soil of medium to low fertility, having a pH of 5.0.
20. How would you prune a mature blueberry bush (a) with a spreading growth habit, (b) with an upright habit?
21. At what stage of maturity, how often, and over how long a period are highbush blueberries harvested in a given region?
22. List an important insect and disease of blueberries.

CURRANTS AND GOOSEBERRIES

23. What are the soil and climatic requirements for gooseberries and currants?
24. In what areas of the United States are commercial currants grown?
25. How are the gooseberry and currant propagated?
26. Give 2 leading varieties of gooseberry and currant.
27. On what type and age wood are currants and gooseberries largely borne?
28. Briefly describe how to prune a mature currant bush.
29. What is a leading disease and insect of currants and gooseberries?

CRANBERRIES

30. Give the five leading states in cranberry production.
31. Briefly list the important factors to consider before establishing a cranberry planting.
32. What are the reasons for flooding a cranberry bog?
33. What varieties are most popular in the East and in the West?
34. How are cranberries harvested, graded, and utilized?

Suggested Collateral Readings

Raspberries and Blackberries

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Butterfield, H. M. Bush berry culture in California. Calif. Agr. Ext. Serv. Cir. 80. 1947.

Darrow, George M. Breeding small fruits. U. S. Dept. of Agr. Yearbook Separate 1583. 1937.

Darrow, George M. Growing erect and trailing blackberries. U. S. Dept. of Agr. Farmers' Bull. 1995. 1948.

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Dodge, B. O. and R. B. Wilcox. Diseases of raspberries and blackberries. U. S. Dept. of Agr. Farmers' Bull. 1488. 1926.

Dougherty, L. A. Markets and prices for New Hampshire berries. N. H. Agr. Exp. Sta. Bull. 321. 1940.

Havis, Leon. The boysenberry in Ohio. Ohio Agr. Exp. Sta. Bimon. Bull. 26: pp. 36–38, No. 209. 1941.

Judkins, Wesley P. The effect of cultivation, straw mulch, and sod plus mulch on the growth and yield of black raspberries. Ohio Agr. Exp. Sta. Bimon. Bull. 30: Sept. to Oct. 1945.

Judkins, Wesley P. The effect of straw mulch, cultivation, and nitrogen fertilizer on the growth and yield of Latham raspberries. Ohio Agr. Exp. Sta. Bimon. Bull. 29: No. 288, pp. 154–158. 1944.

Knowlton, H. E., W. H. Childs, and C. R. Orton. Growing raspberries in West Virginia. W. Va. Agr. Exp. Sta. Cir. 72. 1937.

Shoemaker, J. S. Small fruit culture. Blakiston Co., Phila., 434 pp. 1934.

Shoemaker, J. S., C. W. Bennett, and J. S. Houser. Raspberries and blackberries in Ohio. Ohio Agr. Exp. Sta. Bull. 454. 1930.

Slate, George L. Blackberries and dewberries. N. Y. Agr. Exp. Sta. (Geneva) Cir. 193. 1942.

Slate, G. L., R. F. Suit, and F. G. Mundinger. Raspberry growing in New York: Culture, diseases, and insects. N. Y. Agr. Exp. Sta. (Geneva) Cir. 153. (Revised) 1943.

Vincent, C. L. Vegetable and small fruit growing in toxic ex-orchard soils of central Washington. Wash. Agr. Exp. Sta. Bull. 437. 1944.

Waldo, George F., Ernest H. Wiegand, and Henry Hartman. New berries from Oregon's plant breeding research. Oreg. Agr. Exp. Sta. Bull. 416. 1943.

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Waldo, George F. and Henry Hartman. Raspberry culture in Oregon. Oreg. Agr. Exp. Sta. Bull. 443. 1947.

Zeller, S. M. and Joe Schuh. Diseases and insect pests of cane fruits in Oregon. Oreg. Agr. Exp. Sta. Bull. 418. 1944.

BLUEBERRIES

Bailey, John S., Henry J. Franklin, and Joseph L. Kelley. Blueberry culture in Massachusetts. Mass. Agr. Exp. Sta. Bull. 358. 1939.

Beckwith, Charles S., Stanley Coville, and Charles A. Doehlert. Blueberry culture. New Jersey Agr. Exp. Sta. Cir. 229. 1937.

Brightwell, W. T. and Stanley Johnston. Pruning the high bush blueberry. Mich. Agr. Exp. Sta. Tech. Bull. 192. 1944.

Chandler, F. B. Low-bush blueberries. Maine Agr. Exp. Sta. Bull. 423. 1943.

Coville, Frederick V. Improving the wild blueberry. U. S. Dept. of Agr. Yearbook Separate 1585. 1937.

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Johnston, Stanley. Essentials of blueberry culture. Mich. Agr. Exp. Sta. Cir. 188. 1943.

Markin, Florence L. Blueberry diseases in Maine. Maine Agr. Exp. Sta. Bull. 419. 1943.

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Suit, R. F. Currant leaf spot control. New York Agr. Exp. Sta. (Geneva) Bull. 709. 1945.

Thayer, Paul. The red and white currants: Their history, varieties and classification. Ohio Agr. Exp. Sta. Bull. 371. 1923.

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Bain, H. F., H. F. Bergman, and R. B. Wilcox. Harvesting and handling cultivated cranberries. U. S. Dept. of Agr. Farmers' Bull. 1882. 1942.

Beckwith, Charles S. Cranberry growing in New Jersey. New Jersey Agr. Exp. Sta. Cir. 246. 1931.

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Franklin, Henry J. Cranberry growing in Massachusetts. Mass. Agr. Exp. Sta. Bull. 371. 1940.

Franklin, Henry J., H. F. Bergman, and Neil E. Stevens. Weather in cranberry culture. Mass. Agr. Exp. Sta. Bull. 402. 1943.

Franklin, Henry J. and Neil E. Stevens. Weather and water as factors in cranberry production. Mass. Agr. Exp. Sta. Bull. 433. 1946.

Shoemaker, J. S. Small fruit culture. Chapter VI, Blakiston Co., Phila. 1934.

Wilcox, R. B. Cranberry fruit rots in New Jersey. N. J. Agr. Exp. Sta. Cir. 403. 1940.

Appendix

AGRICULTURAL EXPERIMENT STATIONS AND COLLEGES IN THE UNITED STATES AND CANADA

A list of available bulletins, circulars, and other information regarding temperate fruit growing can be obtained by writing to the agricultural editor of the different agricultural experiment stations and colleges. These publications are usually free, although a few states charge a small fee for those sent outside of the state. Except for a few states, as indicated below, the agricultural experiment stations and colleges of agriculture are located in the same city.

IN UNITED STATES

State	*City*
Alabama	Auburn
Alaska	College
Arizona	Tucson
Arkansas	Fayetteville
California	Berkeley
Colorado	Fort Collins
Connecticut	
College and station	Storrs
Station	New Haven
Delaware	Newark
Florida	Gainesville
Georgia	
College	Athens
Station	Experiment
Hawaii	Honolulu
Idaho	Moscow
Illinois	Urbana
Indiana	Lafayette
Iowa	Ames
Kansas	Manhattan
Kentucky	Lexington
Louisiana	University Station
Maine	Orono
Maryland	College Park
Massachusetts	Amherst
Michigan	East Lansing
Minnesota	St. Paul
Mississippi	State College
Missouri	Columbia
Montana	Bozeman
Nebraska	Lincoln
Nevada	Reno
New Hampshire	Durham
New Jersey	New Brunswick
New Mexico	State College
New York	
College and station	Ithaca
Station	Geneva

IN UNITED STATES—*Continued*

State	*City*	*State*	*City*
North Carolina	Raleigh	South Dakota	Brookings
North Dakota	Fargo	Tennessee	Knoxville
Ohio		Texas	College Station
College	Columbus	Utah	Logan
Station	Wooster	Vermont	Burlington
Oklahoma	Stillwater	Virginia	Blacksburg
Oregon	Corvallis	Washington	Pullman
Pennsylvania	State College	West Virginia	Morgantown
Puerto Rico		Wisconsin	Madison
Insular Station	Rio Piedras	Wyoming	Laramie
College and Federal Station	Mayaguez	United States Department of Agriculture[1]	Washington, D. C.
Rhode Island	Kingston		
South Carolina	Clemson		

IN CANADA

Province	*City*	*Province*	*City*
Alberta	Edmonton	Saskatchewan	Saskatoon
British Columbia	Vancouver	Quebec	Macdonald College
Manitoba	Winnipeg		
Nova Scotia	Truro	Dominion Department of Agriculture	Ottawa
Ontario	Guelph		

ABSTRACT JOURNALS

Many scientific publications are issued monthly, quarterly, or annually, which contain information pertaining to fruit growing. Results of most current publications are briefed into a paragraph or two and published in special abstract journals. Among them are the following:

Biological Abstracts (Plant Science section). University of Pennylvania, Philadelphia 4, Pennsylvania.
Chemical Abstracts. Columbus, Ohio.
Horticultural Abstracts. East Malling, Kent, England.
Review of Applied Mycology. Kew, Surrey, England.

A complete reference index to current agricultural publications for research workers is given in Bibliography of Agriculture, published monthly by the United States Department of Agriculture Library, Washington 25, D. C. Micro-film or photostatic copies of entire articles listed can be obtained through the United States Department of Agriculture at a nominal charge for both foreign and domestic publications.

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[1] A list of Federal agricultural publications arranged by subjects can be obtained by requesting Miscellaneous Publication No. 60 (1945) from the Division of Publications, Office of Information, United States Department of Agriculture, Washington 25, D. C.

SCIENTIFIC JOURNALS

Among the scientific journals in English which frequently or regularly contain articles pertaining to fruit growing are the following:

Agricultural Chemicals. New York, N. Y.
Agriculture in the Americas. Washington 25, D. C.
American Bee Journal. Hamilton, Illinois.
American Journal of Botany. New York Botanical Garden, New York 58, N. Y.
American Society for Horticultural Science, Proceedings. Columbus, Ohio.
American Society of Agronomy, Journal. Geneva, New York.
Annals of Applied Biology. London, England.
Annals of Botany. London, England.
Annals of the Missouri Botanical Garden. St. Louis, Missouri.
Botanical Gazette. Chicago, Illinois.
Botanical Review. Fordham P. O., New York 58, N. Y.
Boyce Thompson Institute for Plant Research, Contributions. Yonkers, New York.
Boyce Thompson Institute for Plant Research, Professional Papers. Yonkers, New York.
Ecology. Brooklyn, New York.
Economic Botany. New York Botanical Garden, New York 58, N. Y.
Hilgardia. Berkeley, California.
Horticultural society proceedings (annual) of important fruit states in the United States. (Contact the respective experiment stations.)
Indian Journal of Agricultural Science. Delhi, India.
Journal of Agricultural Research. Washington 25, D. C.
Journal of Economic Entomology. Menasha, Wisconsin.
Journal of Heredity. Washington, D. C.
Journal of Pomology and Horticultural Science. London, England.
National Horticultural Magazine. Washington, D. C.
National Pecan Association, Proceedings. Mobile, Alabama.
New Phytologist. London, England.
Northern Nut Growers' Association, Annual Report. Geneva, New York.
Phytopathology. Lancaster, Pennsylvania.
Plant Physiology. Lancaster, Pennsylvania.
Queensland Agricultural Journal. Brisbane, Australia.
Refrigerating Engineering. New York 18, N. Y.
Royal Society of London, Proceedings. Series B. London, England.
Science, Lancaster, Pennsylvania.
Scientific Agriculture. Ottawa, Ontario, Canada.
Soil Science, Baltimore, Maryland.
Tasmanian Fruitgrower and Farmer. Franklin, Tasmania.
Tropical Agriculture. St. Augustine, Trinidad, British West Indies.
Yearbook of the California Avocado Society. Los Angeles, California.

POPULAR FRUIT GROWING JOURNALS

Among the journals containing fruit growing information are the following:

American Fruit Grower Magazine. Cleveland 13, Ohio.
American Nurseryman. Chicago, Illinois.
Australian Dried Fruits News. (Australian Dried Fruits Association.) Mildura, Victoria, Australia.
Better Fruit. Portland 14, Oregon.
The Blue Anchor. Sacramento, California.
California Citrograph. Los Angeles 14, California.
California Fruit News. San Francisco, California.
California Fruit and Grape Grower. San Francisco 3, California.
Calavo News (Calavo Growers of California). Los Angeles, California.
Canadian Food Packer. Gardenvale, Quebec.
Canadian Horticulture and Home Magazine (Fruit Edition). Oshawa, Canada.
Canner. Chicago, Illinois.
Food Packer. Chicago 2, Illinois. (Formerly, Canning Age.)
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SCIENTIFIC NAME OF SOME OF OUR COMMON FRUITS

Common Name	Scientific Name
The Apple	*Malus pumila*
The European or Common American Pear	*Pyrus communis*
The Sand Pear	*Pyrus pyrifolia*
The Snow Pear (used in Europe for cider)	*Pyrus nivalis*
The Quince	*Cydonia oblonga*
The Peach	*Prunus persica*
The Nectarine	*Prunus persica var. nectarina*
The Apricot	*Prunus armeniaca*
The Almond	*Prunus amygdalus*
European Plums	
a. The common plum such as Green Gage and Italian prune	*Prunus domestica*
b. The Damsons and others	*Prunus insititia*
American Plums	
a. American plum grows from Maine to Florida and east of Rocky Mountains from Mexico to Canada.	*Prunus americana*
b. Hortulan plum, adapted to southern states but can be grown in North	*Prunus hortulana*
c. Canada plum, suited to colder regions	*Prunus nigra*
d. Wildgoose plum, important in South	*Prunus munsoniana*
Japanese Plums	*Prunus salicina*
The Sour Cherry	*Prunus cerasus*
The Mazzard or Sweet Cherry	*Prunus avium*
The Duke Cherry	*Prunus effusa*
The Southern Muscadine Grapes	*Vitis rotundifolia*
The Eastern Fox Grapes	*Vitis labrusca* or *Labrusca crosses*
The European Old World Grapes (grown on Pacific Coast)	*Vitis vinifera*
The European Red Raspberry	*Rubus idaeus*
The American Red Raspberry	*Rubus idaeus var. strigosus*
The Blackcap Raspberry	*Rubus occidentalis*
The Purple Cane Raspberry	*Rubus neglectus* (hybrid between red and black raspberries)
The American Allegheny Blackberry	*Rubus allegheniensis*
The Himalya Blackberry	*Rubus procerus*
The Evergreen Thornless Blackberry	*Rubus ulmifolius var. inermis*
The Broadleaf Evergreen Blackberry	*Rubus vestitus*
The European Blackberry	*Rubus thyrsoideus*
The Dewberry	
a. Northern dewberry—from Maine westward and southward	*Rubus flagellaris,* and *Rubus invisus*

Common Name	Scientific Name
b. Southern Dewberry	*Rubus trivialis*
c. Western Dewberry (grapeleaf California dewberry)	*Rubus ursinus var. vitifolius*
Red Currants	
a. Common Red Currant	*Ribes sativum*
b. Northern Red Currant	*Ribes rubrum*
The European Black Currant	*Ribes nigrum*
The American (Hairystem) Gooseberry	*Ribes hirtellum*
The European Gooseberry	*Ribes uva-crisca*
The Strawberry	*Fragaria chiloensis X virginiana*
The High Blueberry	*Vaccinium corymbosum*
The Low Blueberry	*Vaccinium angustifolium*
The Large Cranberry	*Vaccinium macrocarpon*
The Small Cranberry	*Vaccinium oxycoccos*

TABLE 43

RETURNS PER HOUR OF LABOR ON DIFFERENT ENTERPRISES ON COST-ACCOUNT FARMS IN NEW YORK STATE FROM 1914 TO 1940[1]

	1914 to 1920	1921 to 1930	1931 to 1933	1934 to 1940
	Dollars	*Dollars*	*Dollars*	*Dollars*
Fruit				
Apples	..	0.76	0.24	0.38
Cherries		...	0.56	0.60
Peaches		...	0.25	0.52
Pears		...	0.16	0.40
Cash crops				
Tomatoes, canning-factory	...	...	0.29	0.37
Cabbage	0.51	0.42	0.29	0.49
Potatoes	0.55	0.75	0.23	0.50
Cucumbers	...	0.37[2]	0.14	...
Beans	0.12	0.13	0.13	0.23
Peas, canning-factory	...	0.57	−0.09	0.30
Grain				
Wheat	0.57	−0.03	0.01	0.56
Corn for grain	0.14	−0.10	0.02	0.22
Barley	−0.03	−0.11	−0.41	0.05
Oats	0.01	−0.17	−0.31	0.02
Buckwheat	0.07	−0.25	−0.08	...
Hay				
Alfalfa	0.97	0.75	0.00	0.57
Other hay	0.88	0.16	−0.22	0.15
Livestock				
Hens	0.67	0.48	0.14	0.28
Raising chicks	...	0.52[3]	0.48	0.31
Cows	0.33	0.31[3]	0.01	0.27
Feeder lambs	...	0.00[3]	0.50	0.12
Sheep	...	−0.30[3]	−0.65	0.13
Hogs	..	0.03[3]	−0.09	0.17

[1] Data from Twenty-five Years of Farm Cost Accounts, by Paul Williamson (Cornell Ext. Bull. 439, 1940), and from later reports by Paul Williamson and J. N. Efferson.

[2] Two years, 1929 and 1930.

[3] Four years, 1927 to 1930.

TABLE 44

PEARS: ITEMIZED COSTS PER AVERAGE ACRE, PER TON, AND PER PACKED-BOX BASIS; HOOD RIVER VALLEY, OREGON, WITH AVERAGE YIELDS (1940–42) AND 1943 PRICES OF MATERIALS AND LABOR[1]

For 417 acres in 17 orchards producing 175,140 loose boxes (39.2 pounds), an average yield of 420 boxes or 8.23 tons per acre.[2]

ITEM	COST PER ACRE	COST PER TON	COST PER BOX[3]	PERCENTAGE OF COST
				Per cent
Labor				
Pruning (27.7 hours per average acre)	$ 18.56	$ 2.26	6.7¢	5.1
Brush removal (6.7 hours per average acre)	4.49	.55	1.6	1.3
Fertilizing (6.2 hours per average acre)	4.15	.50	1.5	1.1
Cultivating (6.9 hours per average acre)	4.62	.56	1.7	1.3
Irrigating (29.2 hours per average acre)	19.56	2.38	7.1	5.4
Spraying (20.5 hours per average acre)	13.74	1.67	5.0	3.8
Thinning[4] (23.0 hours per average acre)	15.41	1.87	5.6	4.2
Propping (11.8 hours per average acre)	7.91	.96	2.8	2.2
Picking (82.0 hours per average acre)	54.94	6.67	19.8	15.1
Other harvesting (21.2 hours per average acre)	14.21	1.73	5.1	3.9
Miscellaneous labor (16.8 hours per average acre)	11.26	1.37	4.0	3.1
Total labor (252 hours per average acre)	$168.85	$ 20.52	60.9¢	46.5
Materials				
Fertilizers	$ 16.81	$ 2.04	6.1¢	4.6
Irrigation water	2.94	.36	1.1	.8
Sprays	26.27	3.19	9.5	7.2
Props, wire, etc.	6.58	.80	2.4	1.8
Picking bags	.62	.08	.2	.2
Ladders	1.00	.12	.3	.3
Lugs	3.81	.46	1.4	1.1
Total materials	$ 58.03	$ 7.05	21.0¢	16.0
General expense				
Machinery repair	$ 10.71	$ 1.30	3.9¢	2.9
Motor fuel	11.47	1.39	4.1	3.2
Building repair	5.61	.68	2.0	1.5
Electricity and water	2.67	.32	1.0	.7
Tree replacement	4.56	.55	1.6	1.3
Fire insurance	2.00	.24	.7	.6
Liability insurance	4.45	.54	1.6	1.2
Telephone and office	2.58	.31	.9	.7
Taxes	6.95	.84	2.5	1.9
Other and miscellaneous	5.45	.67	2.0	1.5
Total general expense	$ 56.45	$ 6.84	20.3¢	15.5

(*Continued on following Page*)

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[1] Includes all costs, delivered to the packing house or cannery door.

[2] Data from Kuhlman, G. W., J. H. Blosser, and D. C. Mumford. Cost of producing apples and pears in the Hood River Valley, Oregon. Oreg. Agr. Exp. Sta. Bull. 429. 1945.

[3] The number of packed boxes was computed as 66 per cent of the loose boxes or 277 packed boxes per acre.

[4] The Bartlett pear was practically the only variety thinned. The thinning of Bartletts alone is estimated at 82.5 man hours per acre thinned or 59.4 hours per average acre.

TABLE 44—*Continued*

Item	Cost per Acre	Cost per Ton	Cost per Box[3]	Percentage of Cost
Depreciation				
Machinery	$ 12.70	$ 1.54	4.6¢	3.5
Buildings	7.18	.88	2.6	2.0
Total depreciation	$ 19.88	$ 2.42	7.2¢	5.5
Interest at 5%				
Machinery	$ 4.80	$ .58	1.7¢	1.3
Buildings	9.82	1.19	3.5	2.7
Cash for operating	7.38	.90	2.7	2.0
Orchard	38.16	4.64	13.8	10.5
Total interest	$ 60.16	$ 7.31	21.7¢	16.5
Total cost	$363.37	$ 44.14	131.1¢	100.0

TABLE 45

HOURS OF MAN LABOR BY OPERATIONS IN MICHIGAN APPLE AND PEAR ORCHARDS, 1943[1]

Operation	Hours per Acre
Apples[2]	
Growing	
Pruning and brush removal	15.7
Spreading fertilizer	1.2
Spraying	20.9
Cultivating	1.5
Thinning fruit	4.2
Mulching trees	1.6
Miscellaneous work	5.9
Total	51.0
Harvesting	
Picking	34.0
Total to grow and pick 108-bushel yield	85.0
Total to grow and pick 185-bushel yield	126.0

(*Table continued on page 618.*)

TABLE 45—*Continued*

Operation	Hours per Acre
Pears[3]	
Growing	
Pruning and brush removal	23.6
Spreading fertilizer	1.6
Spraying	16.2
Cultivating	3.0
Thinning fruit	1.3
Blight control	1.6
Miscellaneous	2.9
Total	50.2
Harvesting	
Picking	18.4
Total for growing and harvesting	68.6

[1] From: Wright, K. T. and Walter Toenjes. Apple and pear costs. Mich. Agr. Exp. Sta. Cir. Bull. 202. 1946.

[2] Based on 91 orchards, average 38 acres each with 31 acres in bearing. About 30 per cent were under 20 acres, 41 per cent from 20 to 39 acres, and 29 per cent were 40 acres or more, up to a maximum of 225 acres.

[3] Based on 45 orchards, averaging 15 acres each about two-thirds of which were in bearing. About four-tenths of orchards were less than 10 acres, and one-sixth over 25 acres, up to maximum of 50 acres. Average yield was 45 bushels per acre.

TABLE 46

APPLES: ITEMIZED COSTS PER AVERAGE ACRE, PER TON, AND PER PACKED-BOX BASIS; HOOD RIVER VALLEY, OREGON, WITH AVERAGE YIELDS (1940–42) AND 1943 PRICES OF MATERIALS AND LABOR[1]

For 502 Acres in 16 Orchards Producing 273,088 Loose Boxes (34.8 Pounds), an Average Yield of 544 Boxes or 9½ Tons per Acre.[2]

Item	Cost per Acre	Cost per Ton	Cost per Box[3]	Percentage of Cost
				Per cent
Labor				
Pruning (47.2 hours per average acre)	$ 33.04	$ 3.49	11.7¢	7.5
Brush removal (10 hours per average acre)	7.00	.74	2.5	1.6
Fertilizing (4.2 hours per average acre)	2.94	.31	1.0	.7
Cultivating (7.5 hours per average acre)	5.25	.56	1.9	1.2
Irrigating (29.5 hours per average acre)	20.65	2.18	7.3	4.7
Spraying (30.7 hours per average acre)	21.49	2.27	7.5	4.9
Thinning (103 hours per average acre)	61.80	6.53	21.9	14.1
Propping (8.7 hours per average acre)	6.09	.64	2.2	1.4
Picking (109.2 hours per average acre)	74.26	7.84	26.3	16.9
Other harvesting (30.8 hours per average acre)	21.56	2.28	7.6	4.9
Miscellaneous labor (23.2 hours per average acre)	16.24	1.72	5.7	3.7
Total labor (404 hours per average acre)	$270.32	$ 28.56	95.6¢	61.6

(*Table continued on page 619.*)

TABLE 46—*Continued*

ITEM	COST PER ACRE	COST PER TON	COST PER BOX[3]	PERCENTAGE OF COST
Materials				
Fertilizers	$ 14.16	$ 1.50	5.0¢	3.2
Irrigation water	2.69	.28	1.0	.6
Sprays	21.38	2.26	7.5	4.9
Props, wire, etc.	2.47	.26	.9	.6
Picking bags	.55	.06	.2	.1
Ladders	.94	.10	.3	.2
Lugs	3.14	.33	1.1	.7
Total materials	$ 45.33	$ 4.79	16.0¢	10.3
General Expense				
Machinery repair	$ 10.15	$ 1.07	3.6¢	2.3
Motor fuel	11.28	1.19	4.0	2.6
Building repair	3.72	.39	1.3	.8
Electricity and water	1.84	.19	.6	.4
Tree replacement	6.31	.67	2.2	1.4
Fire insurance	1.29	.14	.5	.3
Liability insurance	7.50	.79	2.6	1.7
Telephone and office	1.67	.18	.6	.4
Taxes	6.80	.72	2.4	1.6
Other and miscellaneous	3.82	.40	1.4	.9
Total general expense	$ 54.38	$ 5.74	19.2¢	12.4
Depreciation				
Machinery	$ 12.04	$ 1.27	4.2¢	2.7
Buildings	5.54	.59	2.0	1.3
Total depreciation	$ 17.58	$ 1.86	6.2¢	4.0
Interest at 5%				
Machinery	$ 4.41	$ .47	1.6¢	1.0
Buildings	6.93	.73	2.4	1.6
Cash for operating	8.61	.91	3.0	2.0
Orchard	31.35	3.31	11.1	7.1
Total interest	$ 51.30	$ 5.42	18.1¢	11.7
Total cost	$438.91	$ 46.37	155.1¢	100.0

[1] Includes all costs, delivered to the packing house or cannery door.

[2] Data from: Kuhlman, Gustav W., John H. Blosser, and D. Curtis Mumford. Cost of producing apples and pears in the Hood River Valley, Oregon. Oreg. Agr. Exp. Sta. Bull. 429. July 1945.

[3] The number of packed boxes was computed at 52 per cent of the loose boxes or 283 packed boxes per acre.

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